THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 51 Thursday, September 6, 1934 No. 942

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Contents

	PAGE
Back to the Starting Post	143
Bearing Metals	143
District Presidents.—No. 2	144
The Institute of Vitreous Enamellers	144
Who's Who in Vitreous Enamelling	144
Electric Cast-Iron Practice	145
Tensile Strength of Steel at Low Temperatures	148
The Aims and Objects of the Institute of British Foundrymen	149
Time-Saving Tables for Patternmakers	152
Imported Bolts, Nuts, Nails, etc.	152
London Foundry Class	152
The Work of Walter Rosenhain	153
This Week's News in Brief	155
Trade Talk	155
Obituary	155
Personal	155
Raw Material Markets	156
Contracts Open	156

Back to the Starting Post

About twelve years ago, we were discussing with Mr. Ronceray the question of the relative "life" of steels made by various processes. As a result of this conversation Mr. Ronceray decided that the French equivalent was *coulabilité*. Some time later, Mr. Cury, an eminent French metallurgist, published his researches into the *coulabilité* of alloys using a graduated spiral mould as a medium for the expression of his results. The worth of this test was quickly recognised internationally, and since that time experiments have been carried out in all the principal manufacturing countries of the world.

Some of the results have been translated into English, and we find that the spiral test is now indiscriminately referred to as "castability," "fluidity," and "viscosity," with or without qualification by the adjective relative. The spiral test, it should be remembered, has a complex significance, inasmuch as it may refer to the running of liquid metal into a mould prepared under standard conditions or the filling of a mould of standard dimensions, but varied as to sand composition, ramming density, and surface finish by a metal of known composition cast at predetermined temperatures. Under the conditions outlined by the latter part of the previous sentence, it will be readily granted that the test definitely relates to the ability of metal to fill a mould as influenced by mould conditions, whereas the earlier part related to figures which are a function of some properties of the metal itself. In routine testing the two cannot be disassociated. It does not seem appropriate, therefore, to speak of the test in words which relate only to a property of a liquid, such as "viscosity," "fluidity," or "castability."

An intelligent foundryman will, on occasion, assert that a certain metal may be fluid, but that it has no "life" under the conditions under which it has to be used, as he mentally associates its state with the moulds to be filled. From the above, it will be clear that the evolution of the spiral test was an effort by the metallurgist to express arithmetically a property referred to by foundrymen as "life," that it has reference both to metal and mould, and that the best name that can be accorded to it is the foundry "life" test. Once there is a general acquiescence of its dual association with both metal and mould, there should be a complete disassociation with the scientifically ascertainable properties of metal or alloys *per se*. As the test is the concrete expression of a property involving melting point, pouring temperature, viscosity and receptacle, it is of paramount practical interest, best describable by the simple term "life."

Bearing Metals

Bearing metals in one form or another have always constituted a considerable proportion of the output of the non-ferrous side of the foundry industry. For many years the old-established alloys, developed almost entirely by rule-of-thumb methods, were sufficient for the needs of the engineering industry, but in the last few years both engineering design and economic pressure have led to far greater demands being made upon this type of material. On the one hand, higher bearing temperatures and pressures have led to the development of the lead bronzes, while economic considerations have resulted in the improvement of the lead-base white metals. More recently the whole range of cast-bearing metals has suffered competition from the needle-roller bearing.

The one outstanding feature of bearing-metal practice in the past has been the lack of fundamental ideas on the properties required in a bearing. Certainly it has been an accepted dogma that a duplex type of microstructure was essential, having a hard constituent embedded in a relatively soft matrix. Further than this, however, very little has been established as to the precise physical properties which contribute to the success of a bearing alloy; no scientific basis has been evolved for the prediction of the suitability of new alloys or for the improvement of existing materials. It is, therefore, a refreshing change to find this question of the assessment of the relative merits of bearing metals and the mechanism of their success and failure forming the subject of such an admirable series of Papers and such full discussion as was the case at the autumn meeting of the Institute of Metals, held this week in Manchester. The Papers referred to, dealing with the improvement of white bearing metals for severe service and their behaviour under various deformation tests, represent a part of the programme of research being undertaken by the International Tin Research and Development Council, under the direction of Mr. D. J. Macnaughtan. Consideration is given to the theoretical functions of an ideal white metal and the mechanism of failure by the formation of fatigue cracks, while the directions in which improvements in service properties of white metals may be secured are fully analysed, but probably the most valuable part of the series is that dealing with the results of indentation, tensile and pounding tests carried out upon a

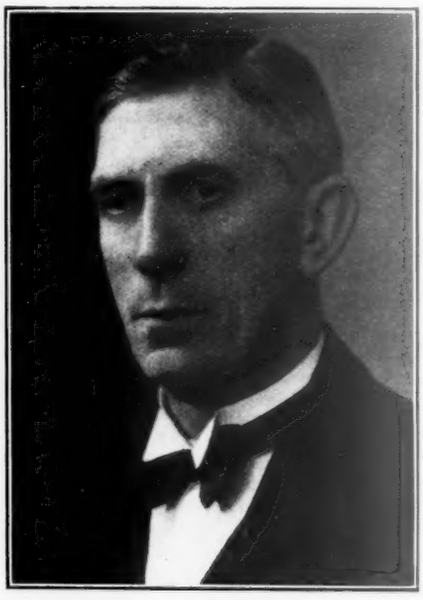
XUM

range of tin-base and lead-base alloys containing in certain cases additions of other elements, such as magnesium, nickel and cadmium. The hardness of the various metallographic constituents of the white metals and their softening on heating to 100 deg. C. were measured by both scratch and micro-indentation methods, and two new and relatively simple tests are suggested for the measurement of ductility, cracking stress and damping effect. One of the most interesting findings is that small additions of cadmium have an appreciable effect in improving the properties of Babbitt metal.

District Presidents.—No. 2

MIDDLESBROUGH BRANCH OF THE INSTITUTE OF BRITISH FOUNDRYMEN

The new President of the Middlesbrough Branch, Mr. James Hackwood, was one of the founders of the Branch, and has been a member of the Council since it was formed. He is also



MR. J. HACKWOOD.

President this year of the Middlesbrough and District Foremen Engineers' and Chief Draughtsmen's Association, of which he has been a member for 21 years. It is worth noting that he is only the third foundryman to be President of the Association during its 66 years of existence.

Mr. Hackwood is foundry foreman with Messrs. Cochrane & Company, Limited, of Middlesbrough, whom he has served for 39 years. He has held his present position, first as assistant, then as chief foreman, for 21 years.

Canadian Nickel Production

The world consumption of nickel in 1934 is expected to reach about 150 million lbs., as compared with 96 million lbs. last year and the 1929 record total of 136 million lbs. Nickel exports by the International Nickel Company of Canada during the first half of this year were well ahead of any similar period during the company's history, being 250 per cent. greater than the 1932 total for the entire year. Sales by Falconbridge Nickel Mines, Limited, are also well in line with production. Exports of nickel by the International Nickel Company during the first quarter of this year were valued at $7,653,763, and in the second quarter $7,562,130, as against $2,194,424 and $5,455,997 respectively for the corresponding quarters of last year.

The Institute of Vitreous Enamellers

FIRST ANNUAL CONFERENCE IN BIRMINGHAM

As previously announced, the first annual conference of the Institute of Vitreous Enamellers is to take place in Birmingham on September 28, 29 and 30, 1934. A banquet and dance will be held in the Grosvenor Room, Grand Hotel, Birmingham, on Friday, September 28, 1934, to inaugurate the first annual three-day conference. The Lord Mayor of Birmingham has kindly consented to attend the banquet, and he will be supported by prominent leaders of industry, commerce and scientific societies closely connected with the enamelling industry.

The Council feel they can confidently count upon every individual member giving this initial venture his personal support, and that they will further ensure its success by inviting their friends and associates connected with the industry who, apart from enjoying the social amenities that the conference period offers are likely, in the near future, to become members of the Institute. The Committee desire to stress the fact that they are anxious to make the event a success; therefore all friends of members and prospective members, particularly the ladies, will be warmly welcomed.

Programme

FRIDAY, SEPTEMBER 28.

7.00 p.m.—Reception at the Grand Hotel by Dr. J. W. Mellor, F.R.S., President of the Institute, and Alderman H. E. Goodby, Lord Mayor of Birmingham.

7.30 p.m.—Banquet.

10.00 p.m. to 2.00 a.m.—Dancing in the Grosvenor Room, with Horace Janes' "Lyricals," and exhibition dancing by Horace Janes and Nora Grice, Midland professional ballroom champions and world finalists.

SATURDAY, SEPTEMBER 29.

9.30 a.m.—Assemble at the Grand Hotel.

9.45 a.m.—Motor coaches leave for a visit to the works of Messrs. Parkinson Stove Company, Limited, Stechford.

1.00 p.m.—Lunch at the Grand Hotel.

2.30 p.m.—Technical meeting at the Grand Hotel: (*a*) Presidential address; (*b*) presentation and discussion of a Paper on "Vitreous Enamelling," by A. England, M.Sc.

5.00 p.m.—Tea.

7.30 p.m.—Visit to the Prince of Wales Theatre for a performance of "Lilac Time."

11.00 p.m.—Supper at the Grand Hotel.

SUNDAY, SEPTEMBER 30.

10.45 a.m.—Assemble at the Grand Hotel.

11.00 a.m.—Service at the Cathedral of Birmingham.

1.00 p.m.—Lunch at the Grand Hotel.

2.30 p.m.—Motor coaches leave for a visit to the Botanical Gardens, Harborne.

5.00 p.m.—Tea in the gardens.

Anyone who is interested in vitreous enamelling and desires to attend the conference should write immediately to Mr. W. Todd, Honorary Conference Secretary, c/o Messrs. Parkinson Stove Company, Limited, Stechford, Birmingham.

Alloy Cast-Iron Grate Bars

An American foundry supplying grate bars to a local gas company is using an alloy cast iron containing 1 per cent. nickel and 0.35 per cent. chromium, which is reported to give a considerably longer life than ordinary cast iron. Before using nickel and chromium additions, 24 grate bars were supplied every two months, but since the adoption of the alloy cast iron 12 grate bars every six months are sufficient. In other words, the life of the grate bars is increased six times by using the alloy cast iron.

Who's Who in Vitreous Enamelling

No. 4.—MR. J. H. COUPE

Mr. J. H. Coupe, who is a founder member of the Institute of Vitreous Enamellers, is the works manager and engineer of Messrs. Belling & Company, manufacturers of electric heating and cooking appliances. Mr. Coupe was born and educated in Yorkshire. He served his apprenticeship with Messrs. George Wright & Company, of Rotherham, engaged in the production of coal ranges and fires, passing through the workshops and drawing office, and eventually choosing designing as a career.

As a designer of high-class coal ranges and fireplaces, he held appointments with Messrs. Steel & Garlands, Limited, and Longden & Company, being with the latter firm 6 years, and leaving there to join the Davis Gas Stove Company, Luton, being in charge of the drawing office for a period of 6 years.

Following this experience in heating and cooking with coal and gas, he joined Messrs. Belling

MR. J. H. COUPE.

& Company in 1915, applying his specialised experience in the production of the electrical heating and cooking appliances which this firm has made so popular.

Belling & Company's self-contained works at Enfield is one of the largest in the country devoted to the manufacture of electrical fires, cookers and domestic appliances. Mr. Coupe took over his present position in 1922, and has been responsible for building, equipping and organising the present works, which includes a large foundry, fireclay department, and a modern vitreous-enamelling plant. The latter section is now being extended to accommodate a further five muffles.

Mr. Coupe takes a very active interest in matters concerning the vitreous-enamelling trade, and is a prominent member of the executive council of the Institute.

Canadian Copper for Great Britain

Great Britain's purchases of Canadian copper increased during the first six months of this year from 16,090 tons in 1933 to 22,110 tons this year. Canada sold more copper in Great Britain than in any other country during the period in question. Great Britain imports of zinc from Canada represented 60 per cent. of the total, amounting to 36,850 tons, as against 21,331 tons during the first half of last year.

Electric Cast-Iron Practice

By H. H. Walther (Metallurgist, The Dayton Steel Foundry Company, Dayton, Ohio)

Just as only a comparatively few years ago the very exacting demands of the automobile industry forced the improvement of steel and led to the commercial introduction of alloy steels and their production heat-treatment, so now this same industry, more than any other, has forced the improvement of cast and malleable irons, either plain or alloyed, and their heat-treatment. This improvement has been so great that the weak, brittle irons of just a few years ago bear no resemblance whatsoever to the strong, tough irons of to-day. In fact, many

Fig. 1.—Cupola Iron. × 100 Unetched.

of the newer alloyed irons are as strong as medium-carbon steels, and, when heat-treated, have even replaced alloy-steel forgings. These improved irons find their greatest application in heat- or wear-resisting products, such as brake drums, clutch plates, cylinder heads and blocks, exhaust manifolds, exhaust-valve seats, valve guides, gears, camshafts, and crankshafts. In the commercial fields they not only find applications where strength and heat- and wear-resistant properties are of paramount importance, but also for those purposes for which a close, dense iron capable of taking a high polish, definitely free of porosity or other defects, is required, such as for dies, tyre and bottle moulds, paper presses and cylinders, etc.

To-day the electric furnace is capable of producing consistently, and perhaps more easily than any other melting process, plain irons ranging from 15 to 20 tons per sq. in., alloyed irons of 18 to 29 tons per sq. in., and even alloyed irons which, when properly heat-treated, will exceed 45 tons per sq. in. and have an appreciable elongation. While these irons all are in commercial production and, when judiciously selected, are indispensable for a particular application, it has been personal experience as foundrymen that many engineers, learning of the high strengths available in the irons to-day, have blindly specified that a piece be made of a 20 tons per sq. in. iron, when such a value would be unnecessary and the increased cost, both of the metal and increased time of machining, would make it prohibitive for mass production. Conversely, many parts that now are made of ordinary irons may be redesigned to take full advantage of the high-test irons, and the reduction of a third to a half of the weight of the casting would result in a desirable economy. Furthermore, many engineers are still specifying that all tensile bars be cut from the 1¼-in. bar, regardless of the section size of the casting. This practice is unfair to all, for a test-bar cut from this section may show only a value of 20 tons per sq. in., while a piece cut from the casting, such as a $\frac{5}{16}$-in. section of a brake drum, would show for the same iron 24.5 to 25.9 tons per sq. in.

The diversified means by which these improvements were achieved, and the important *rôle* played by the electric furnace in the development of these irons are beyond the scope of this Paper[1], and the author will confine himself merely to a few practical points on the manufacture of electric cast irons for automobile and allied products.

Factors Contributing to the Selection of the Electric Furnace Process

A very brief analysis of the requirements for an automobile iron, especially those characteristics governed by the melting unit may facilitate the discussion of the factors contributing to the selection of the electric-furnace process. They are:—(*a*) Great strength combined with a high impact value; (*b*) wear resistance; (*c*) minimum grain growth; and (*d*) definite uniformity of chemical analysis, physical properties and microstructures.

Other requirements for this metal governed more by the proper choice of alloys rather than the melting medium are:—(*a*) Strength at elevated temperatures (650 deg. C.); (*b*) high fatigue value at elevated temperatures (650 deg. C.); and (*c*) ability to remain true to size and form in service. Iron suitable for this service must have a minimum tensile of 20 tons per sq. in., since less than that would necessitate heavier sections and add to the undesirable unsprung weight of the vehicle. Extensive preliminary work conducted in a 50-lb. capacity 'Lectromelt laboratory furnace checking against cupola irons, proved conclusively that for equal analysis of metal and equal melting and pouring temperatures, electric-furnace iron was 2 to 3 tons per sq. in. stronger than cupola iron. This may directly be attributed to the denser, thoroughly deoxidised and degasified condition of the electric-furnace product. It is well known that a low total carbon naturally produces the stronger iron.

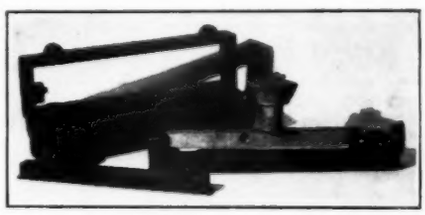


Fig. 3.—Shrink-Test Apparatus.

After carefully checking the other variables entering into such a highly-specialised product, a total carbon range of 2.70 to 2.80 per cent. was finally established. The cupola may melt irons in this range under carefully-regulated conditions and when using large amounts of steel scrap, but has the disadvantage of large erratic carbon pick-up if much superheating or holding at superheat temperatures is attempted. Also large amounts of steel scrap require an increased volume of air for the melting and the molten iron dripping through the ascending air current may become oxidised or occlude other gases. The iron in an electric furnace is melted under a neutral or reducing atmosphere and consequently not subjected to oxidising conditions.

Perhaps the greatest advantage of the electric furnace is the ease of superheating and holding at superheat temperatures, for the purpose of refining the graphite. The physical state of this constituent such as form, size and distribution, probably more than any other element profoundly influences the ultimate properties of the iron. Small rounded or nodular graphite, uniformly distributed throughout the mass, preserves the continuity of the matrix and prevents localised areas of stress at the sharp edge of the large graphite flakes so common to cupola irons. These fine graphite particles, other elements remaining

Fig. 2.—Electric Furnace Iron. × 100 Unetched.

constant, increase the tensile, transverse, wear resistance and impact values of the iron, and at the same time minimise the tendency to growth. Figs. 1 and 2 illustrate the graphite formation and distribution in two irons of approximately the same analysis, one of a cupola iron and the other of a superheated electric-furnace iron. They strikingly visualise the very superior product possible with the electric process.

The sulphur pick-up with the cupola averages 0.03 per cent. for each melting. With the electric furnace there is no pick-up and consequently a cheaper raw material may be used. Uniformity, both of chemical analysis and physical properties are essential in any highly-stressed specialised product. An iron which is exceptionally successful for brake drums showed the following analysis:—T.C., 2.70 to 2.80; Si, 2.40 to 2.80; Mn, 0.70 to 0.80; S, 0.05 max.; P, 0.10 max, and Mo, 0.50 per cent.; the Brinell hardness was 200 to 220; the tensile strength 20 tons (min.) (on casting); the transverse strength 5,000 lbs. (min.); associated with a deflection 0.12 in. (min.).

Out of a series of *50 consecutive heats* chosen at random from approximately 1,200 heats, only three were beyond the total-carbon limits, the maximum variation from the range was 0.07 per cent., while 49 of the heats were within the manganese limits. All the drums were within the specified Brinell range. Tensile and transverse tests are not made of each heat, but the 11 bars tested in this series of heats were above the minimum figure.

Alloy control is simple with the electric furnace. The thorough stirring of the bath, both by convection currents and electro-dynamic action, ensure absolute homogeneity of the metal. Also

[1] "The Manufacture of Acid Electric Steel and Cast Iron," H. H. Walther. "Iron and Steel Engineer," vol. viii, No. X. October, 1931, pp. 415-422.

easily-oxidised elements like chromium may be added with the charge and chromium scrap remelted without loss.

There is no need to use expensive pig-iron if scrap of the desired phosphorus and sulphur content is available. This results in a desirable economy. Also the foundry scrap, since it has not become oxidised in the melting, may be remelted as often as desired without impairing the final product. Cheap borings may also be used and they require no baling.

The disadvantages of an electric furnace are a high installation cost and a high melting cost, especially during periods of very reduced production. The improved qualities of the product, however, easily overcome these disadvantages.

Furnace Equipment

The plant with which the writer is connected is devoted to the manufacture of specialised products of iron and steel for the automobile industry. These widely-dissimilar metals are melted in either of two 3-ton-per-hour, three-phase, direct arc 'Lectromelt furnaces, which are used interchangeably for the cold batch-melting of alternate heats of cast iron and steel. No special precautions, other than the self-evident one of completely draining the furnace before charging the following differing heat, is necessary for this practice.

One furnace has a power input of 1,800 k.v.a., while the other has 1,500 k.v.a. Current is supplied at 6,600 volts and transformed to 138 volts for the high or melting tap, and 94 volts for the low or refining tap. To prevent excessive surging and ensure steady operation, 20 per cent. reactance is used on high tap and 10 per cent. on low.

These electric furnaces not only provide an efficient and very flexible melting unit, but also allow the pouring of two or even three small batches of widely-varying carbon and silicon irons from the same heat, each batch being well within the close chemical limits desired and superheated and poured at the correct temperature.

While one furnace is equipped with 8-in. graphite electrodes and the other with 10-in. carbon, it has been observed in a period of over three years no superiority of the one electrode over the other, either in the quality of the metal or the ultimate cost per ton.

The entire shell of both furnaces (side walls and bottom) is lined with a monolithic or rammed-in ganister lining. Repairing the side walls is simple and cheap. As a rule, one man can easily do the work in 4 to 6 hours for each 1,100-1,200 tons. Very seldom will the furnace lining be in such a bad condition that it necessitates the removal of the roof and the insertion of forms to do the patching. It may be interesting to note that the older of the two furnaces was installed in 1923, has melted over 9,700 heats, averaging 4 tons each, and yet has the original bottom and most of the side walls intact. The roofs are of silica brick, and on mixed heats of iron and steel have an average life of 800 to 900 tons.

Melting Costs

Due to the varying ratios of cast iron and steel produced during a given period, and the difficulty in allocating each metal its true proportion of the fixed charges and overhead, it is thought the easiest method of deriving the cost of electric-furnace iron will be, first, briefly to analyse the total melting costs of the two metals.

In Table I, melting costs covering an average four-week period of 1932 are given. Since they cover a period of very reduced production, they naturally will be higher than those of normal production.

These figures may appear high for cast iron, but recognition should be taken of the fact that this is a specialised product, highly alloyed and of low phosphorus content. Commercial irons may be made considerably cheaper than this, since pig-iron may be entirely eliminated and the entire charge composed of a cheaper cast-iron scrap, borings and steel.

Production so far has warranted only cold-batch melting. However, it is understood that very favourable costs are being achieved elsewhere, either by hot duplexing or continuous cold melting. Some figures recently inspected have indicated that, with the latter two methods, metal is being produced at a cost lower even than for cupola practice.

TABLE I.—*Melting Cost Four-Week Period.*

	Total cost.	Cost per net ton melted.
Direct materials	$6,226.88	$12.22
Direct labour	334.05	
Direct labour bonus	42.78	
Total direct labour	376.83	0.74
Indirect labour	26.37	
Indirect labour bonus	22.08	
Allocated maintenance labour	141.39	
Total indirect pay-roll	189.84	0.37
Supplies (deoxidisers, sleeves, stoppers, etc.)	111.75	
Grinding wheels	2.63	
Electrodes	570.31	
Electric current	5,633.00	
Gas (for preheating ladles)	51.42	
Lighting supplies	0.27	
Water	69.23	
Maintenance of equipment (refractories, etc.)	178.22	
Industrial insurance	1.51	
Total materials and service	6,618.34	12.99
Assigned depreciation of equipment	474.24	
Taxes on equipment	63.30	
Total fixed charges	537.54	1.06
Grant total expense	13,949.43	27.38

TABLE II.—*Average Cast-Iron Heat during same Period. Direct Materials.*

	Amount.	Price.	Total.
Foreign cast-iron scrap	$900	$0.00450	$4.05
Foundry cast-iron scrap	1,000	0.00446	4.46
Foundry cast-iron borings	1,000	0.00290	2.90
Steel scrap	1,300	0.00548	7.12
Steel turnings	500	0.00290	1.45
Pig-iron	300	0.00750	2.25
50 per cent. Fe–Si	80	0.03379	2.70
80 per cent. Fe–Mn	10	0.03730	0.37
Molyte	43	0.28660	12.32
Petroleum coke	60	0.0120	0.72
	5,193		38.34

Total Direct Material.

	Per net ton.	Total.
Direct labour	$0.74	$1.89
Indirect labour	0.37	0.95
Materials and service	12.99	33.25
Fixed charges	1.06	2.71
Total		38.80
Grand total	$77.14	
Cost per net ton	$29.74	

Melting Procedure

The furnaces are charged by means of the charging pans so familiar to users of this type of furnace. In this way a 2-ton charge may be introduced in 3 min. The same rules for proportioning and positioning the heavy and light pieces in the furnace apply to cast iron as they do to steel. The metallurgical control is very simple. Briefly, the charge is so calculated that it will finish at the desired carbon content, while the silicon content is kept somewhat lower than is required in the final product. When readings of the optical pyrometer have shown that a temperature of 1,675 deg. C. has been attained, the calculated amount of ferro-manganese is thrown in and the arc is kept on 2 min. longer in order to disseminate thoroughly the alloy throughout the bath. Power is then thrown off and a preliminary test taken. This is the familiar wedge test[2] and is eminently suitable for all control work. Only in exceptionally particular cases is a preliminary carbon analysis necessary. The appearance of the fracture in experienced hands gives an indication of the amount of ferro-silicon necessary to obtain the required carbon-silicon ratio.

The necessary amount of ferro-silicon is introduced, well stirred, and the metal again checked by the wedge test. If this proves that the composition is correct, the furnace is tapped into a bottom-pour ladle. The metal is chilled with cast-iron scrap to a temperature of 1,510 deg. C. and poured at that temperature.

Personal experience has been that it is much simpler and more reliable to obtain the C-Si ratio by the procedure outlined above, than is the case where the charge is calculated to finish at the required silicon content with a slightly higher carbon content, and the carbon then diluted by means of steel scrap. The required silicon content also may be obtained directly by silica reduction in the furnace [$2C+SiO_2=2CO+Si$] instead of by ferro-silicon, but the latter method is much quicker and reliable.

Whilst this brief outline may have indicated that the furnace operations for cast iron are very simple, yet the fact remains that in practice many factors are involved. Economical operations demand that the expensive pig-iron be kept at a minimum, while as much cast-iron scrap be used as possible without impairing the final analysis. Large amounts of low-phosphorus and sulphur steel scrap should be used, the carbon deficiency being made up by additions of petroleum coke. For rapid absorption of the carbon the coke should be placed as low as possible in the charge in order to allow all the molten metal to trickle over it. In fact, with a cold furnace the coke is introduced directly upon the bottom of the furnace. Obviously, all of the low-carbon scrap should be in contact with the coke. The usual procedure is to charge the steel turnings first, followed with the coke, steel scrap, pig- or cast-iron scrap, and cast-iron borings on top. The carbon-absorption efficiency rarely exceeds 75 per cent. and consequently at least 25 to 35 per cent. excess coke must be charged. Since the absorption rate is faster with a low-silicon bath, the charge should be as low as possible in silicon. Extremely high-duty irons are produced synthetically and very economically in the electric furnace from 100 per cent. steel scrap carburised with petroleum coke. However, the increased time for the reaction renders the process almost prohibitive in production where time is a vital factor and heats must be poured every 1½ to 2 hrs. In such cases economical operations seldom warrant that more than 1.5 per cent. carbon pick-up be attempted. In other words, the charge would consist essentially of 60 to 70 per cent. steel and 30 to 40 per cent. pig or cast iron, plus coke.

Engineers are just recognising a fact long known to metallurgists, namely, that irons of identically similar chemical analysis may have widely-varying physical and machining characteristics due to the size, form and distribution of the graphite particles. If the latter are coarse and overlapping the iron will be weak and brittle; if they are very fine, rounded, and uniformly distributed throughout the mass the iron will be strong and tough under impact. The ease with which this graphite formation can be

[2] *Ibid.* "Description of Wedge Test." Page 421.

controlled is peculiar to the electric furnace. For example, if a bath of metal containing coarse graphite flakes is merely melted and poured, the resultant metal would still retain the original coarse graphite particles. If, however, this same metal is held in the furnace for a considerable length of time, or for a shorter period of time at a higher temperature, more and more of the graphite would dissolve, until eventually no free graphite nuclei would remain. From this metal at a point somewhat under the solidification range of the iron the graphite will precipitate, and due to the absence of any free carbon nuclei upon which to collect and agglomerate, it will be precipitated in a very finely-divided, nodular form similar to the formation observed in malleable irons. Between these two extremes the graphite formation may be held under perfect control. Here again, the wedge test is a valuable instrument for quickly determining the amount of refining the metal has undergone. The wedge is broken at a section corresponding to the casting section and the fracture examined. If it appears dull and coarse grained, indicative of an insufficiently refined metal, it is merely necessary to reduce the graphite nuclei concentration by holding the bath for a slightly longer period, perhaps at a higher temperature. At this point additions of steel and coke are also a rapid medium for quickly refining the metal. On the other hand, if the fracture has a fine, silky, close-grained appearance, indicating a highly-refined metal, and the casting does not warrant high strength, whilst ease of machining is the determining factor, it merely is necessary to increase the graphite nuclei concentration by additions of soft pig-iron or preferably by soft, coarse iron of the same chemical analysis as the bath.

In all cases where the graphite nuclei have been dissolved by superheating, or where the refining has been accomplished by steel and coke additions, in which case the carbon absorbed will have no crystal form of its own, to introduce a small amount of graphite nuclei analogous to the "seeding" of a solution to induce crystallisation in the chemical laboratory. For high-test irons it is obvious that the "seeding" be done by the introduction of high-duty iron scrap, *i.e.*, scrap containing the graphite in nodular form, and of the same chemical analysis as the bath. This scrap is conveniently charged in the furnace just prior to the final silicon additions.

It is commonly believed that, when a ladle of superheated iron, *i.e.*, an iron having very fine nodular graphite, is chilled, either with common cast iron or other material carrying coarse graphite, that the graphite of the entire mass of metal in the ladle will be precipitated in coarse flakes. Unfortunately, we have not thoroughly investigated this phenomenon for all types of iron. The molybdenum-alloyed irons in the carbon ranges mentioned in the Paper were studied, and they did not exhibit this phenomenon. Samples taken from the first and the last of the ladle (an average interval of 30 minutes) revealed no perceptible change in structure, the fine nodular graphite persisting. Iron of a high silicon content, or containing appreciable amounts of other graphitising alloys, showed considerable coarsening of the graphite flakes during the same interval, probably by the agglomeration of fine particles.

In Table III a representative cast-iron heat has been logged.

Fig. 4.—Fracture from 8-in. Cylinder of Mo-Alloyed Electric-Furnace Iron.

When two or more small batches of metal of varying carbon content are required from the same heat, the procedure is to calculate the charge for the lowest carbon content. The required amount is tapped out, and, if necessary, graphitised or softened by ferro-silicon additions to the ladle. The slag is then thoroughly removed from the metal remaining in the furnace, and fine petroleum coke scattered over the surface of the bath. Agitating the metal, both by stirring and rocking of the furnace, accelerates the rate of carbon absorption. While the carbon content has been raised to 1.30 per cent. with a yield of 75 per cent. of the carbon addition by this method, it is thought that a carbon pick-up of 0.80 per cent. is the maximum amount to be attempted for economical commercial production.

The shrink-test apparatus shown in Fig. 3 has proved to be a very valuable factor in control work, since it has often revealed "off-grade analysis" heats even before the final results were reported from the chemical laboratory.

Physical Properties of Representative Irons

Perhaps the most outstanding characteristic of the electric-furnace, low total-carbon, molybdenum-alloyed iron is its close, dense grain and uniform structure throughout the piece, even in large sections. In Fig. 4 is shown a fracture taken from the middle of a cylinder 8 in. in diameter and 30 in. long. No perceptible difference in grain size from the outer edge to the centre is observed in the piece, while Brinell readings at the intervals shown were identical. A difference of 0.04 per cent. combined carbon was obtained between the points marked A and B on the print. Tensile bars cut from the exact centre and the outer edge checked within 10 cwts. per sq. in.

Clutch plates are usually poured from the same mixture as brake drums. Average chemical and physical results for the high and low total-carbon limits are:—T.C., 2.70 to 2.80 per cent.; Tensile strength, 22.9 to 23.7 tons per sq. in.; transverse strength, 5,250 to 5,100 lbs. per sq. in.; and deflection, 0.16 to 0.14 in.

Cylinder heads, due to their more complicated

Table III.—*Log of an Aver age Cast-Iron Heat.*

Bought cast-iron scrap	1,000 lbs.
Domestic cast-iron scrap	1,375 „
Domestic cast-iron borings	675 „
Low phosphorus pig-iron	900 „
Steel scrap	650 „
Molyte	36 „
Petroleum coke	25 „

Time, min.	Meter reading, kw.-h.	Deg. C.	T.C.	Si.	Mn.	Remarks.
0	0	—	3.00	2.10	0.60	Start charging (calculated charge).
3.5	0	—	—	—	—	Finish charging.
4.8	0	—	—	—	—	Power on—*High Tap.*
11	282	—	—	—	—	*Low Tap.*
31	677	1,370	2.81	2.39	0.58	—
36	752	1,440	2.81	2.37	0.58	—
40	860	1,485	2.80	2.39	0.57	—
43	902	1,540	2.81	2.38	0.55	—
47	996	1,595	2.80	2.41	0.54	—
50	1,072	1,650	2.80	2.44	0.51	Power off added 19 lbs. Fe-Mn, 25 lbs. Fe-Si 1st preliminary.
53	—	—	2.78	2.66	0.84	Results of 1st preliminary, add 10 lbs. Fe-Si.
57	—	—	2.79	2.73	0.82	Results of 2nd test.
64	—	1,605	2.77	2.74	0.80	Tapped heat chilled in ladle (test taken from furnace stream).
69	—	1,510	2.74	2.68	0.77	Poured first mould (power already on for next heat).
85	—	1,480	2.73	2.64	0.76	Poured test-bar (chemical and physical test below).
102	—	1,450	2.71	2.58	0.74	Last mould.

Drums poured	121	Weight per drum	36 lbs.
T.C.	2.73	Brinell—first drum	217
C.C	0.72	Brinell—last drum	214
Si	2.64	Tensile	22 tons per sq. in.
Mn	0.77	Transverse	5,100 lbs. (1¼ in. dia., 12 in. centres).
Mo	0.52		
P	0.107	Deflection	0.13 in.
S	0.043	Shrinkage	0.17 in. per ft.

design, are usually poured of a higher carbon iron in order to prevent foundry difficulties An average analysis would be:—T.C., 3.11; Si, 2.37; Mn, 0.85; S, 0.039; P, 0.103; and Mo, 0.52 per cent.; tensile strength, 20.6 tons per sq in.; transverse strength, 4,800 lbs. per sq. in.; and deflection, 0.14 in.

For gears and crankshafts for small compressors and pumps and various other commercial applications of a like nature, a heat-treated molybdenum iron is often used. It contains 2.70 to 2.80 T.C. and 0.50 per cent. Mo.

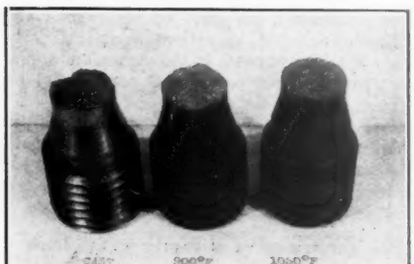


FIG. 5.—FRACTURES OF HEAT-TREATED MO-ALLOYED ELECTRIC-FURNACE IRON.

Typical fractures of this iron are shown in Fig. 5.

A recently-developed iron which promises to find many uses where extremely high strength, wear resistance and fatigue properties are necessary, and which has successfully replaced alloy-steel forgings in several instances, contains:—2.70 to 2.80 per cent. carbon, 1.20 to 1.40 per cent. silicon, and 0.80 per cent. molybdenum. This is cast white, graphitised at 925 deg. C., air cooled to 540 deg. C., reheated and oil quenched from 816 deg. C., and drawn at 705 deg. C., with an air cool. This iron has a tensile of 40 to 45 tons per sq. in. with a 2 per cent. elongation.

Electric irons are not limited to the light or specialised class of work. There are numerous heavy applications, *e.g.*, in paper-making rolls, dies, bottle moulds, etc., where the slightest defect or porosity will render the entire casting valueless. Here the strong, dense electric

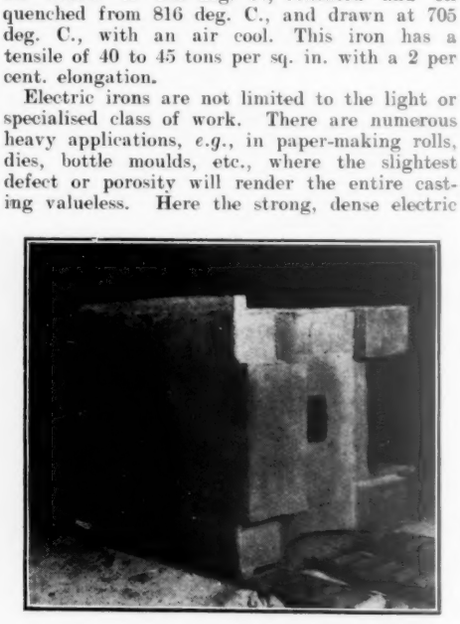


FIG. 6.—BASE OF AN 80-TON PAPER PRESS. 9,700-LB. CASTING OF MO-ALLOYED ELECTRIC-FURNACE IRON.

iron, even should it carry a slightly higher molten metal cost, has a promising tonnage field. High-duty electric irons have proved to be of exceptionally great value in paper rolls, since the dense structure ensures the taking of a high polish, while the very finely, uniformly-distributed graphite particles prevent smudging of the papers. In Fig. 6 is shown the base of an 80-ton paper press, weighing over 4 tons, in the rough cast of electric-furnace molybdenum-alloyed iron.

Heat-Treatment

The heat-treatment of cast iron, although a comparatively recent innovation, is creating considerable interest at the present time. Regardless of its ultimate object, the prime requisite for its successful treatment is close, dense metal. Electric cast iron invariably meets these requirements, and therefore may justify a few brief comments upon the subject.

Ageing.—For the relief of strains a simple anneal at 427 to 538 deg. C. suffices. Care should be taken to heat or cool slowly through the range between 260 to 427 deg. C. Complicated castings, and products like brake drums and other automobile irons which must be machined within very close tolerances and remain true in service, are benefited by this treatment. While apparently it may add to the cost of the finished product, the savings due to the freedom from warpage during machining more than offset the slight expense involved. It has been personal experience that the low total-carbon irons, with their higher shrinkage, are very susceptible to internal strains. Artificially seasoning all low-carbon irons is therefore justified.

Softening.—For easier machining castings may be annealed or rather graphitised by a short soaking at 660 deg. C. The rate of graphitisation depends upon the composition of the metal and may easily be standardised for any analysis of iron by experimental methods.

Quenching.—Cast irons are usually quenched at 816 deg. C., the exact temperature depending upon the analysis of the metal. Oil is preferred, since cold water appears to be too drastic for such a heterogeneous material. In order to derive any appreciable benefit from such a treatment, it is necessary to start with a dense iron of fairly high combined carbon content; 0.55 per cent. combined being the minimum. Tempering temperatures are generally higher than those for steel, the usual procedure being to oil-quench at 816 deg. C. and temper at 563 deg. C. Care should be taken to thoroughly soak the piece at the quenching temperature, but not to unnecessarily prolong this soaking, as graphitisation will take place and the final object worse than before the quench. In heating, either for softening or hardening, the piece should be brought to temperature gradually, at least through the first 400 deg. C.

Hard Spots.—Even with the most exacting foundry control, castings having hard spots or chilled corners are occasionally produced. To render these spots machinable and yet not excessively soften the rest of the casting is often very puzzling. No set rules apply in this case. Some praiseworthy results have been achieved by heating at 945 deg. C. to break up the carbides, furnace cooling to 660 deg. C. and immediately cooling in still air. The castings are then returned to the furnace for the relief of strains which may have been induced. The treatment is obviously unsuitable for hard spots due to chromium carbides.

(This Paper was presented to the Association Technique de Fonderie by the author on behalf of the American Foundrymen's Association.)

Mrs. M. E. Stubbs

Mrs. Mary E. Stubbs, widow of the late W. T. Stubbs, who was president of the Manchester Chamber of Commerce from 1910 to 1912, died on Monday at sea on board the steamer "Kraljica Marija." Mrs. Stubbs was on holiday at the time of her death. Her remains will be taken to Venice, where they will be cremated. A funeral service will be held in Manchester next week. Mrs. Stubbs was chairman of directors of the engineering firm, Joseph Stubbs, Limited, of Ancoats and Openshaw. She was an aunt of Mr. Roy Stubbs, President of the Institute of British Foundrymen. She had always been a keen woman of business, and will be remembered also for her gift of land for a children's camp in Cheshire.

Tensile Strength of Steel at Low Temperatures

The knowledge of the properties of steels at low temperatures has been amplified to include lower temperatures by recent research by G. GRUSCHKA, described in No. 364 of the "Forschungsarbeiten über Ingenieurwesen," of the Verein deutscher Ingenieure. The point of interest in this work is that the temperatures worked at were below the freezing point of carbon dioxide, while other similar work has been carried on at appreciably higher low temperatures. By means of skilfully-designed apparatus, the temperature was progressively reduced to −183 deg. C., the boiling point of nitrogen at atmospheric pressure, at which the test samples were maintained throughout the tensile test. A special device was also used for the accurate measurement of the elongation. Owing to the marked sensitivity to notching of steels at these low temperatures, a special form of test-piece was employed. Tests were made with Armco iron, seven non-alloy steels with 0.08 to 0.4 per cent. C and 0.35 to 0.8 per cent. Mn, three nickel steels with approx. 0.12 per cent. C and 3 to 5 per cent. Ni, and a chrome-nickel steel with 0.23 per cent. C, 0.71 per cent. Cr and 3.77 per cent. Ni.

As already found in previous researches, the tensile strength and the yield point were again shown to increase gradually with falling temperature down to −130 deg., but more rapidly at still lower temperatures. Also at these low temperatures these two physical values were found to increase linearly with the carbon content, exactly as found at ordinary temperatures. The addition of manganese did not modify the tensile strength according to any apparent law. The necking-down and elongation varied with decreasing temperature, but the temperature-elongation curves plotted for the different steels tested all showed a discontinuity, the temperature range in which this occurred depending on the composition. As the temperature is reduced below zero, the curves exhibit only a small negative gradient, until at a critical temperature there is a sudden drop in value by up to 85 per cent. of the normal value at ordinary temperatures. According to the composition, this discontinuity in elongation is situated between −140 and −185 deg., but with nickel steels is at still lower temperatures. Thus in a 3 per cent. Ni steel it lies between −183 and −195 deg., while a 5 per cent. Ni steel reveals no discontinuity even at −195 deg. Again, a variation in the content of manganese was found to have no regular effect on this characteristic.

Colorimetric Estimation of Phosphorus

G. VAN DER LINGEN in the "Analyst" recommends in place of sodium sulphate and hydroquinone for the reduction of precipitated phospho-molybdate in the colorimetric estimation of phosphorus the use of sodium sulphate and p-methylaminophenol sulphate ("Elon"), the time for reduction being 20 min.

Iron and Steel Trade in Sweden

The monthly report of the Swedish Ironworks Association (Järnverksföreningen) states that the pig-iron trade was quiet in July. The tone of the market was, however, firm, and towards the end of the month prices advanced from 99 to 100 cr. per long ton, f.o.b., mainly as the result of decreasing stocks. Pig-iron consumption in the home market has shown a steady increase. Exports of high-grade steels were maintained, in spite of a temporary weakness. Steel prices were unchanged with a hardening tendency. Trade with Great Britain and Continental countries was good, but with the United States was slack. In the home market, steel demand is increasing, with prices on a firmer basis. The outlook is, nevertheless, regarded as uncertain, owing to the unstable political situation.

The Aims and Objects of the Institute of British Foundrymen*

By T. Makemson

For many years, people engaged in professions or similar skilled occupations have formed themselves into societies or associations for the advancement and development of professional knowledge. Some of these societies also deal with questions of professional conduct, and in some cases even decide as to who is qualified to practice the profession, others have a more purely altruistic aim and devote their attention to increasing existing knowledge associated with their particular field for the benefit of their members, and usually, also for the benefit of the community in general.

The oldest society of this kind associated with engineering is the Institution of Civil Engineers, which was founded in 1818 and obtained a Royal Charter in 1828. Later, the Institution of Mechanical Engineers was established, and at a still later date the Institution of Electrical Engineers. As engineering and other technical and scientific pursuits developed and multiplied in number, numerous other similar organisations of a more or less specialised character came into existence. To-day, there are many such societies connected with various branches of the engineering and metallurgical industries alone, whilst almost every occupation which has a scientific and technical basis has at least one society of a national character which is endeavouring to promote progress in the field which it covers.

The Institute of British Foundrymen was established in 1904 by a few enthusiastic and far-seeing men in the industry, who realised that progress could only be made by substituting scientific method for rule of thumb, and free interchange of opinion and experience for secretiveness. They were encouraged by the success of the then recently formed American Foundrymen's Association, and they derived considerable inspiration and practical support from the recently established Foundry Trade Journal; support which has been maintained ever since to the advantage of the industry. In the year 1921 the Association was considered to be carrying out work of such importance that it was granted a Royal Charter, and opportunity was taken to change its name to the Institute of British Foundrymen.

Mr. F. J. Cook, one of the founders of the Institute, in a Paper on its history which he presented some years ago, says:

> "The primary object was considered to be purely educational—the education of the man actually at work in the foundry, such as workmen, foremen and managers. This was to be followed by educating those outside the shops who are more or less directly or indirectly concerned with it, such as draughtsmen, patternmakers, proprietors and works managers, etc. As an incentive to membership the subscription was placed at the absurdly low figure of 7s. 6d. per annum. It was also definitely decided that the Association should not countenance any discussion of Trade Union matters, whether appertaining to wages or conditions of labour. Further, the Association was not to be used in any sort of propaganda for business houses in the selling and advertising of their goods. The success which has followed the ideals set up in those early days proves that the Association was well and wisely governed from its inception."

It is thirty years since those ideals were formed. It is not easy to adhere to one's ideals for thirty years, and the ideal of an annual subscription of 7s. 6d. was abandoned at an early date, but in the main the principles which were established in those days have been the guiding principles of the Institute's policy ever since.

The "objects" of the Institute as set out in the Royal Charter are:—

> "To promote the intellectual welfare of its members by periodical meetings for reading and discussion of scientific Papers on subjects connected with the foundry and allied industries.
>
> "To initiate, conduct and supervise researches into the science and technology of the art of metal and alloy production, casting and working. Organise and conduct or advise on means and systems of education for all or any grades of operatives or workers in the art and craft of metal casting, and to collect and distribute information on the science and art of founding and allied subjects."

These objects are comprehensive and the Charter allows considerable latitude in the methods to be employed in pursuing them; the Charter does, however, imply certain limitations, for example, it is not allowed to engage in commerce.

Papers and Discussions

In reviewing its work, the activities which come to mind first are those which centre around the work of the Branches and the Annual Conferences—the reading and discussion of Papers and inspection of works. This is, of course, the type of work carried out by most similar organisations. The value of works inspections is obvious, and one can often trace improvements in one's practice and procedure to suggestions acquired during such visits. It is, however, not quite so easy to trace the influence of certain Papers one has heard or read. These Papers do have influence, however. Much of the detail may be forgotten, but the outlook of foundrymen is moulded and foundry experience is enriched, unconsciously, perhaps, by what they have heard and read. Much of that which one reads in the daily papers is forgotten, but this reading colours one's outlook on life, opinions and judgment. Just as no intelligent man would think of ignoring his daily paper, so no intelligent foundryman can afford to ignore the opportunities of maintaining a progressive mind which are afforded by hearing and reading Papers on foundry subjects, and by discussing his problems with his fellows. Think of some of the features which have become prominent in foundry practice during the past twenty-five years; systematic and scientific cupola control, the employment of oil-sand cores, the use of high-duty irons and alloy irons, the control of mixtures by analysis instead of by recipe, and many similar developments which have permeated the whole industry. The fact that they have ceased to be novelties and "new fangled ideas" is due largely to the information on these subjects which has been disseminated throughout the industry by Papers given to the Institute. Would any of these developments have taken place so rapidly and so thoroughly had there been no Institute of British Foundrymen?

Encouragement of Research

At the Sheffield Conference in 1918, Mr. Robert Buchanan, the first President of the Institute, read a Paper in which he pleaded for the establishment of a National Information Bureau for Foundrymen. He visualised that the function of such a bureau would be to abstract the large amount of knowledge and data of value to the foundrymen which was already in existence, and make it available for practical application. He also realised that research work would be necessary at a later date. About the same period the Government granted the sum of one million pounds for expenditure on industrial research through the medium of research associations, and Mr. Buchanan and his associates realised that the most practicable way of participating in grants from this fund was to establish a separate organisation rather than to attempt to carry out the scheme directly through the Institute of British Foundrymen, and so the British Cast Iron Research Association came into existence.

As is well known, this Association has carried out the intention of its founders by operating a bureau of information and by the establishment of perhaps the most complete library on cast iron in the world. Additionally, it has carried out an immense amount of research work of a most valuable character. These facilities are primarily available for the use of members of the Association, and are not necessarily available to members of this Institute as such. On the other hand, members of the staff of the Association do frequently present to technical societies important Papers based on their research work, and this Institute has been favoured with a large proportion of such Papers, so that much of the work of the Association is actually available to our members.

There has always been a close relationship and mutual understanding between the Association and this Institute, and many members of the Association's staff render valuable services to it as members of its various committees and as honorary officials. The Institute also receives valuable co-operation of a similar character from the British Non-Ferrous Metals Research Association.

The Technical Committee

Whilst fully recognising the value of the work of the research associations, it was realised a few years ago that a technical organisation within the Institute was necessary to cover certain aspects of its work and enable its members to take full advantage of the results of such research work as were given to it from time to time; about four years ago, therefore, the Institute established its Technical Committee. This committee consists partly of members who are elected by the Branches, and partly of members who are co-opted by reason of their special knowledge or experience of some branch of the work of the committee. In order to prevent overlapping, and to promote co-operation, the committee drew up a statement of its aims and of its relationship to the British Cast Iron Research Association. The aims of the committee may be summarised from this statement as follow:—

> "To make recommendations in respect of any technical matter which may be submitted to the Institute by an outside body.
>
> To keep in touch with our own representatives on outside bodies, such as the British Standards Institution, and to make recommendations to them embodying the opinion of members of the Institute.
>
> To ascertain from Institute members what aspects of current practice and difficulty require investigation.
>
> To collect and disseminate scientific information of value to the industry.
>
> To furnish the British Cast Iron Research Association with suggestions in carrying out their research programme and assist them, if necessary, by furnishing samples and assistance."

It will be seen that the Technical Committee is that part of the Institute's organisation which makes contact with other organisations whose work is of importance to it, and, furthermore, it endeavours to review the whole field of technical development in the foundry industry for the benefit of its members.

* An address given to the London Branch of the Institute, Mr. A. S. Beech presiding.

XUM

Work of the Sub-Committee

The Technical Committee operates mainly through a number of specialised sub-committees, those in existence at present dealing respectively with the subjects of cast iron, malleable cast iron, steel castings, non-ferrous castings, melting furnaces, sands and refractories and foundry costing. Several of the sub-committee's commenced their work by reviewing the specifications dealing with the respective types of castings in which they were interested. They found, as would be expected, that there was an unnecessarily large number of specifications in use, and that many of the requirements of buyers could be equally satisfied by the adoption of an appropriate standard specification, and in several cases they were successful in inducing purchasing bodies to adopt a standard specification.

The examination of specifications indicated to these committees several lines of useful investigation work which they commenced to follow. The members of the Committee on Malleable Cast Iron, for example, found it desirable to carry out a large amount of investigation relating to the general subject of tests. Size and shape of test-bars, the electro-magnetic properties of malleable, and the correlation of microstructure with mechanical properties were some of the subjects which they investigated very fully. An interim report on this work was given to the Newcastle Conference in 1932. A year later, the Sand and Refractories Sub-Committee presented a Paper in which they reviewed various methods of sand testing, and in which they endeavoured to put forward recommendations on the relative value of these methods for various types of tests. At the Manchester Conference, in June, the Cast Iron Sub-Committee put forward a Paper giving the results of practical investigations by their members on a variety of subjects, such as contraction, porosity in iron castings, particularly as influenced by phosphorus, and upon other phenomena which could best be investigated on an industrial scale. The youngest sub-committee, that on foundry costing, is reviewing the whole field of foundry costing, and has prepared a report upon one aspect of its work, that of melting costs, which will be submitted to several Branches during the coming session. The remaining sub-committees are all engaged in similar work, the results of which will doubtless be published in due course.

These Papers are interim reports—all scientific work is interim—but they are full of suggestions to the progressive foundryman, and they all contain much matter of immediate practical use. Such Papers introduce a new departure in Institute work, that is, the preparation of Papers by groups instead of by individuals. Each committee is composed of men of varied experience, who are all experts in the committee's field. They pool their ideas, discuss them and criticise them, and the resulting Paper represents the considered views of an authoritative body.

Inquiry Bureau

From time to time, members have sent to the Institute inquiries on some aspect of foundry technique. It may be that a member has heard of some new development and wishes to know where he can obtain further information; he may be experiencing difficulty and wishes to know if there is any published information which will help him; or he may make a direct request for advice to help in the solution of a problem. Members have sometimes sought information on the experiences of other members with certain processes or certain types of plant. In all cases, such inquiries were passed on to a member who was known to be in a position to supply the desired information, and every effort was made to help the inquirer. About two years ago, the General Council authorised the Technical Committee to constitute itself as the recognised medium for dealing with such inquiries, and whereas previous to this time inquiries were dealt with on an unofficial basis, the Inquiry Bureau is now an integral part of the Institute's organisation. Members are invited, in fact urged, to make inquiries on foundry practice, to submit their problems and to seek advice. Such inquiries should be sent to the general secretary, who passes them to the Convener of the Technical Committee. He, in turn, submits them to the appropriate sub-committee or sub-committees, because more than one subject may be involved. The members of the sub-committees include members with all types of experience and knowledge, and this inquiry service is only made possible by the goodwill and the generous help which these members of the Technical Committee render to their fellow-members. The Bureau has dealt with a very large number of inquiries since its establishment two years ago.

One word of explanation is necessary. This service is not competitive with the inquiry bureaux of the research association, nor the work of foundry consultants. Many of the problems which reach the Bureau are such as would never reach either the research associations nor the consultants. The members of the former are mainly firms; Institute members are chiefly individuals. The problems which are submitted to consultants are usually also from firms, and frequently involve a considerable amount of labour to give a solution. Nevertheless, some of the members have problems of their own; a student or an ambitious young foundryman may require help, or a more experienced member may require guidance on some difficulty which he has encountered. The Institute feels that such members have a right to expect assistance, and the Technical Committee endeavours to render such assistance.

Foundry Exhibition

As the Charter does not permit the Institute to engage in trade, it is not permitted to organise foundry exhibitions. Such exhibitions in this country are, however, organised extremely well by the Foundry Trades' Equipment and Supplies Association, and by Messrs. F. W. Bridges & Sons. Recognising the educational value of such exhibitions, the Institute endeavours to give them all the support within its power, and strongly encourages its members to attend. It accepted the invitation of the organisers to arrange a technical exhibit at the exhibition held in April of last year, and this work was delegated to the Technical Committee. The members of the committee, with the aid of their firms and their friends, were entirely responsible for the organisation and management of the exhibit with the very generous co-operation of the exhibition organisers. The exhibit consisted of castings, specimens, test-bars, diagrams and apparatus, and was directed, firstly, to indicate what could be accomplished by the foundrymen, and, secondly, to indicate to the foundryman himself how he could improve his own practice availing himself of modern scientific developments. The exhibit did succeed in accomplishing its objects and, incidentally, was the means of adding about thirty new members to the roll.

Education of Apprentices and Students

One clause of the Charter permits us "to organise and conduct, or advise on means and systems of education for all or any grades of operatives," etc., and the Institute has always taken a serious view of the responsibilities which this clause implies.

As early as 1915, a General Council Committee commenced to investigate the prevailing conditions of apprenticeship and technical training, but this work was interrupted by the war and was not resumed. Since that time apprentices have been encouraged in a general but indefinite way to attend classes. In 1922 the Newcastle Branch was formed, the first Junior Section, and other Junior Sections followed soon afterwards. Their aim was to arouse in the young men a deeper interest in both the practical and technical aspects of their work, but unfortunately, most of the young men did not even take an interest in the Junior Sections, and all but one has now been closed.

In 1928, following on letters received from members of the Institute, the General Council decided to endeavour to inaugurate examinations in foundry practice and in patternmaking of a national character, as distinct from the regional examinations which technical school students had taken hitherto. As a result, the City and Guilds examinations in these subjects were inaugurated, and since their inception three years ago, 260 candidates have sat for the various examinations. The examinations have been passed by 160 of these candidates, who have been awarded certificates endorsed by the President of this Institute.

The City and Guilds of London Institute is assisted in the management of these examinations by an Advisory Committee, upon which this Institute is largely represented. The members of the Advisory Committee have given much assistance in the preparation of syllabuses and regulations, and the general organisation of the examinations.

It may be urged that the mere holding of an examination is not the solution of the problem of training foundry apprentices, and this is admitted. The value of the examinations lies in the fact that their establishment has been a distinct encouragement to students to apply themselves to a course of study, the successful completion of which is recognised by the granting of a certificate of national standing. Furthermore, since the examinations were organised on the present basis, several new classes have come into existence in various parts of the country, in fact, facilities for preparing students are in excess of the demand, and although the number of students throughout the country is encouraging, it is desirable that many more should take advantage of the facilities offered. The important feature is that the foundry apprentice has the same opportunities of technical training as apprentices in other engineering trades, and it can be expected that, as a result, a better type of apprentice will be attracted to the foundry trade.

There is a distinct keenness on the part of the education authorities to organise classes in foundry subjects, providing they can be assured of a reasonable number of students, and as the industry will undoubtedly benefit from this educational work, it is plainly the duty of members to support the education authorities and encourage the attendance of students.

The City and Guilds examinations are intended essentially to meet the requirements of the intelligent and ambitious craftsmen, although the syllabus does imply a certain fundamental technical training which is sufficiently broad to form a basis for more advanced work.

In order to meet the requirements of a more advanced type of students, the well-known National Certificate in Mechanical Engineering granted by the Institution of Mechanical Engineers, and the Board of Education, may be endorsed by the President of this Institute in respect of special foundry or metallurgical subjects which have been included in the course leading to the certificate. Several colleges have in operation courses suitable for candidates who wish to obtain this special endorsement. Possession of this certificate indicates that the holder has had a really thorough training, practically of Degree standard, in mechanical engineering, and also a certain amount of training in subjects of practical value to a man who hopes to hold a responsible position in the foundry trade.

Arising out of further correspondence from interested members of the Institute, and of a Paper given by Mr. V. C. Faulkner in Loughborough some time ago, the University of Sheffield, at the request of the Institute, has now inaugurated a day course in metallurgy, specially arranged for students who hope to enter the foundry industry. The course leads to a degree

in the case of matriculated students, and to the Associateship of Metallurgy for those who have not matriculated. The course has been inaugurated largely at the request of this Institute, and a Committee of the Institute has been responsible for much of the preliminary work, including the raising of the necessary funds.

The University graduate in the foundry trade is not a new departure, many such men known to us all are engaged actively in the industry, but their university courses were usually in metallurgy or engineering. There is room for such men and the demand will increase; the new course will provide a training for them definitely directed for the industry they wish to enter. Furthermore, the fact that a degree in foundry practice may be obtained does give the trade and the Institute a distinctly higher standing.

Reference must also be made to a course which it is hoped to inaugurate in Birmingham, and for which Mr. J. G. Pearce is mainly responsible. This will be a twelve months' intensive course for men who are already in the industry, and will be similar to the well-known and highly-successful foundry school in Paris. Although the Institute cannot claim the credit for having inaugurated this course, it has its enthusiastic support.

It will thus be seen that provision is now made for technical training of various grades, from the comparatively simple course required by the intelligent and ambitious workman to the advanced course suitable for the university graduate who wishes to enter the industry.

Employment Register

An aspect of its activities which has developed almost unnoticed, is the endeavour to place members in suitable situations. This activity commenced with an arrangement which the proprietors of THE FOUNDRY TRADE JOURNAL kindly gave the Institute, by which members of the Institute could receive, free of charge, two insertions of an announcement of their requirements in the advertisement columns of the Journal. Employers who are interested in these announcements communicate with the member by letter through the general secretary. In practice, it is found that communication between the two parties is not always made through the medium of correspondence as provided for in the arrangement. The fact that members communicate their requirements to the secretary enables him to register particulars of them and their experience, and to recommend suitable men to employers who inquire for them.

Admittedly, this branch of the work cannot show spectacular results. Many members in need of employment have been unable to obtain it in spite of the help we are able to give them. It is often impossible to find the type of man that is required, and equally it is often impossible to provide the man with the type of position for which his experience is most suitable. In work of this kind one is bound to report many disappointments, but the successes which have been attained have amply justified the establishment of the service. A substantial number of members have obtained suitable positions, and in practically every case, as far as is known, those men are still in the positions obtained for them through the medium of this branch of the Institute's work.

Specifications

The work which members of the Institute carried out in the establishment of the well-known specification for cast iron, B.S.I. 321, is well known. The Institute is invited by the B.S.I. to give its opinion upon all specifications connected, however remotely, with the foundry industry, and this work, as has been explained, is carried out by the Technical Committee. This committee is in contact with various bodies issuing specifications, and through this medium the Institute is able to exert an influence in the preparation of these documents, which are of increasing importance to the founder who has to work to them.

The Institute is represented directly on the Iron and Steel and Non-Ferrous Industry Committees of the B.S.I., and on many of the subcommittees.

International Relations

There are foundry technical associations similar to ourselves, in about eleven countries, and all of these associations are members of the International Committee of Foundry Technical Associations. Several associations, including the I.B.F., provide Papers for the annual conferences of other associations, so that the programme of each of these conferences contains Papers dealing with the work of several foreign countries. Additionally, the International Conferences, which are held each year, provide opportunities for foundrymen to meet their colleagues in other countries, to acquire something of their point of view, and to inspect their foundries. The Institute usually organises the travel and hotel arrangements for the British party.

It is true that only a small number of members are able to avail themselves of the privilege of attending such conferences, but it is true also that the ideas which these members acquire in their visits do gradually permeate and influence foundry practice in their own country. The Exchange Papers which are received from other countries become part of British foundry literature, and as a result of these international relations it is no exaggeration to say that there are few industries which are more in touch with developments in other parts of the world than the foundry industry. As concrete examples, one may refer to the developments in the use of alloy cast iron, and in the mechanisation of foundries. These two features alone are live developments which are engaging increasingly the attention of foundrymen all over the world, and this result is due largely to the interchange of visits and of Papers between the various foundry associations.

Advantages of Membership

It is natural and right that one should inquire as to exactly what benefit one is going to derive from membership of an organisation such as this. Many similar societies have very stringent conditions of admission to membership. They may require that the candidate shall have received his training in a prescribed form; that he shall pass an examination or give evidence of having passed another examination of similar standard, or that he shall have had professional experience of a certain minimum standard for a certain minimum time. By reason of these conditions, membership of such societies indicates to some extent the member's standing, and his certificate of membership is equivalent to a professional diploma. The standing which membership gives is in many cases its greatest attraction, and many people quite properly join such organisations for this reason alone.

There are no such stringent entrance conditions attached to membership of this Institute. All that is asked of the candidate is that he shall be associated with the industry and that he has a desire to promote its technical advancement. Consequently, the only inducements to membership are the personal benefits which membership can give, and a desire to support an organisation which is generously working for the progress of the trade as a whole. It will be seen that those personal benefits are considerable, and an endeavour has been made to explain them in some detail. Perhaps the most important advantage of membership lies in the opportunities it affords of contact with one's fellow-foundrymen, of discussing problems, getting their points of view, and of "talking shop" in the most mutually advantageous manner and under the best conditions. To the man who wishes to keep out of the rut and to keep himself fresh and up to date, "talking shop" at the right time and in the right place is of inestimable value.

It will have been observed that many of the Institute's activities are carried out in a generous and public-spirited manner, with the object of contributing to the technical progress of the industry as a whole. With the exception of a small general office, whose function is to co-ordinate the various units, the whole of the numerous activities are carried out by the members voluntarily, and in their own time and at their own expense.

Perhaps no one is in a better position than the writer, to understand and appreciate the extent and value of this voluntary labour by numerous honorary officials and committee members. The results of such work are enjoyed by the whole industry, and the Institute has a right to expect the industry to give it its support. Many firms and individuals do recognise this obligation, and they support the Institute by their membership, their contributions and by the encouragement and practical assistance they give to those members of their staffs who participate actively. It is found usually that those who are most generous in their support are usually those who are most progressive in their practice. Those who are distrustful of discussion and who will not give the benefits of their experience generally have not much to give, but those who are willing to pool their experience and compare notes find that such a policy has a stimulating effect, and that it keeps them alert and receptive. Secrecy and suspicion lead to decay, whilst mutual discussion leads to progress.

A generation ago the foundry trade was full of trade secrets, and its position was not rated very highly. To-day, thanks to the enlightened attitude for which this Institute is largely responsible, trade secrets have almost vanished, and the industry has revolutionised itself, so that it now commands the respect of other industries as a progressive industry, scientifically and systematically controlled, but still conscious of the value of its centuries of practical experience. Those who are members are assisting in this advancement and are enabling themselves individually to take their places in a rapidly-changing industry. To those who are not assisting by their membership, we would ask that they give their support, and thus acknowledge the indebtedness they owe to those who are contributing to the progress in which they all participate.

Chelsea School of Metallurgy

The Chelsea School of Metallurgy of the Chelsea Polytechnic, Manresa Road, London, S.W.3, has issued its prospectus for the session 1934-35. The School comprises a metallurgical lecture room, a furnace room and dry assay laboratory, a heat-treatment and physical-testing laboratory, a micro-photographic studio and dark room, a research and wet-analysis laboratory and a metal workshop. In addition to providing for the academic study of metallurgy, the courses are designed to meet the requirements of industrial students. Some of the special courses are run in collaboration with local firms. Facilities are also provided for individual and research work for both full-time and part-time students. The evening courses cover an exceptionally wide range. There is a junior course in industrial metallurgy for those apprenticed or employed as engineers, brass finishers, toolmakers, moulders, welders and allied trades; this course extends over two years and consists of 24 lectures and demonstrations followed by practical work. The corresponding senior course is intended for technical representatives and salesmen in engineering firms, those engaged in the ironmongery and brass industry, and all interested, in a productive or administrative capacity, in the production and sale of metallic goods, while there is also a two-year course in engineering metallurgy arranged, primarily, for those studying for the examinations of the engineering institutions and other professional associations. It is also suitable for technical representatives of chemical and chemical-engineering firms and those engaged in a productive, administrative, or consultative capacity in all branches of engineering. Full particulars of the various courses may be obtained from the Principal, Dr. F. J. Harlow.

XUM

Time-Saving Tables for Patternmakers

By A. Buckley

A common but by no means simple task which falls to the lot of the patternmaker at some time or another is that of setting out angles. Without wishing to eulogise on the desirability, or otherwise, of aiming for meticulous accuracy in every instance of angle setting, it will be at once conceded that the error introduced by the use of a protractor of only moderate dimensions (and most patternmakers can boast of such an instrument, usually some relic of their apprenticeship days) is cumulative, resulting in serious error in the case of patterns of large dimensions.

When such a problem arises, it is usual for the patternmaker to fit the protractor head to his combination square and, using it as a bevel, to set it to the required angle by means of the scale on the turret in the protractor head.

TABLE I.—*Amount of Taper in Various Distances.*

Angle.	3 Ft.	2 Ft.	1 Ft.	6 In.	3 In.
Deg.					
½	0.3150	0.2100	0.1050	0.0525	0.0262
1	0.6300	0.4200	0.2100	0.1050	0.0525
1½	0.9432	0.6288	0.3144	0.1572	0.0786
2	1.2564	0.8376	0.4188	0.2094	0.1047
2½	1.5696	1.0464	0.5232	0.2616	0.1308
3	1.8864	1.2576	0.6288	0.3144	0.1572
3½	2.1996	1.4664	0.7332	0.3666	0.1833
4	2.5164	1.6776	0.8388	0.4194	0.2097
4½	2.8332	1.8888	0.9444	0.4722	0.2361
5	3.1500	2.1000	1.0500	0.5250	0.2625
5½	3.4668	2.3112	1.1556	0.5778	0.2889
6	3.7836	2.5224	1.2612	0.6306	0.3153
6½	4.1004	2.7336	1.3668	0.6834	0.3417
7	4.4208	2.9472	1.4736	0.7368	0.3684
7½	4.7376	3.1584	1.5792	0.7896	0.3948
8	5.0580	3.3720	1.6860	0.8430	0.4215
8½	5.3784	3.5856	1.7928	0.8964	0.4482
9	5.7024	3.8016	1.9008	0.9504	0.4752
9½	6.0228	4.0152	2.0076	1.0038	0.5019
10	6.3468	4.2312	2.1156	1.0578	0.5289
15	9.6444	6.4296	3.2148	1.6074	0.8037
20	13.1044	8.7360	4.3680	2.1840	1.0920

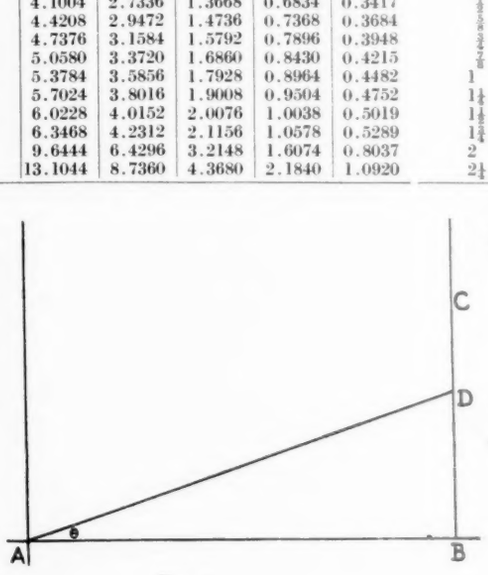


FIG. 1.

The turret, around which the divisions are marked, is generally about 2½ in. diameter, in consequence of which a division representing one degree is in itself a fairly minute measurement (approximating to something very much less than $\frac{1}{32}$ in.), and to subdivide this graduation, in cases where fractional parts of a degree are called for, entails a certain amount of guesswork, resulting in the cumulative error already referred to.

By means of the well-known trigonometrical relationship $\tan \theta = \frac{\text{perpendicular}}{\text{base}}$ a table may be readily computed, giving the amount of taper for any desired angle corresponding to the particular length of the part in question, and correct to four places of decimals. Thus it will be seen that any slight error, if any, will obtain at the point at which it will cause the least amount of inconvenience. Such is given in Table I over Fig. 1, and here it may be mentioned that this has been found particularly useful in setting out lines inclined to one another and where the bevel was too small to reach the apex of the angle. This is a common fault, with adjustable set-squares as used by draughtsmen.

It is a simple task to mark off centre lines at right angles to one another over any distance by the use of straight edge and trammels. Proceeding then as in Fig. 1, the distance A B is marked off as shown and a perpendicular B C erected at B. The angle θ may then be readily constructed by selecting the appropriate value of the length of B D from the Table I given anent the angle required, taking care that the selected value is taken from the column corresponding to the length of the base line A B.

The table given would prove of immense service in most patternshops, and would be well worth constructing in large type for wall display purposes, as its use would result in much time saving. Furthermore, it is by no means complicated, calling for little, if any, skill in its interpretation, and being far superior to the bevel and protractor method in common use.

TABLE II.—*Figures for Setting the Out Gear Cases*

Radius of corner.	Distance of flat from edge.	Radius of corner.	Distance of flat from edge.
In.	In.	In.	In.
$\frac{1}{16}$	0.2927	$2\frac{1}{2}$	1.4635
$\frac{3}{32}$	0.3660	$2\frac{3}{4}$	1.6098
$\frac{1}{8}$	0.4390	3	1.7562
$\frac{5}{32}$	0.5124	$3\frac{1}{2}$	2.0489
1	0.5854	4	2.3416
$1\frac{1}{4}$	0.7317	$4\frac{1}{2}$	2.6343
$1\frac{1}{2}$	0.8781	5	2.9270
$1\frac{3}{4}$	1.0244	$5\frac{1}{2}$	3.2197
2	1.1708	6	3.5124
$2\frac{1}{4}$	1.3171	—	—

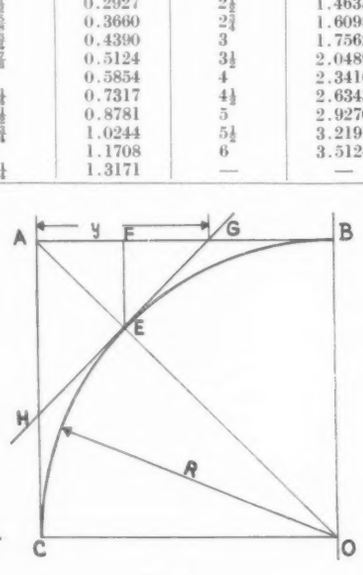


FIG. 2.

Another problem which often proves vexatious to the patternmaker is that of setting out radii for "finishing" the corners of gear-casings and the like. In this connection the following simple method of simplifying this operation may prove of interest, having been found of immense help by the writer.

Referring to Fig. 2, it will be appreciated that it is convenient definitely to locate the distance y preparatory to making a saw-cut in close proximity to the tangent H G and afterwards paring off to the required radius. For those mathematically inclined, the values given in Table II (which should be read in conjunction with Fig. 2) have been computed from the results of the following reasoning

$$AC = OC = R$$

Now $OA = \sqrt{2R^2}$

$$= 1.414\,R$$

Similarly, $AE = 1.414\,AF$

but $AE = OA - OE$

$$= 1.414\,R - R$$

$$= 0.414\,R$$

then $AG = \sqrt{2\,(0.414\,R)^2}$

$$= \sqrt{0.342792\,R^2}$$

or $y = 0.585396\,R$

Imported Bolts, Nuts, Nails, etc.

CHANGES IN CUSTOMS DUTIES

The Treasury, on the recommendation of the Import Duties Advisory Committee, have issued the Additional Import Duties (No. 29) Order, 1934, modifying as from August 30 the Customs duties chargeable on the following (among other) classes of goods :—Articles manufactured wholly or partly of certain non-ferrous metals; circular saws and segments; certain bolts, nuts, and screws; wire nails and staples. A White Paper, containing the Treasury Order and the recommendations of the Advisory Committee to which it gives effect, is published by H.M. Stationery Office.

With regard to articles manufactured wholly or partly of certain non-ferrous metals, the Customs duty on the following goods is raised from 10 to 15 per cent. :—

Articles manufactured wholly of aluminium or of alloys containing more than 50 per cent. by weight of aluminium, the following :—Sheets, strip, plates, discs, and circles, if plain and exceeding 0.006 of an inch in thickness and not plated, coated, drilled, or punched; bars (other than notch bars), rods, wire, tubes, angles, shapes, and sections, not plated, coated, drilled, or punched.

Articles manufactured wholly of copper or of alloys containing more than 50 per cent. by weight of copper, the following :—Sheets, strip, plates, discs, and circles, if plain and exceeding 0.006 of an inch in thickness and not plated, coated, drilled, or punched.

Wire Nails and Staples

The duties on nails (including hob nails, staples, tacks and boot and shoe studs and spikes) will be at the following rates, subject to a minimum duty of 20 per cent. *ad valorem* :—Two inches in length and over, £4 a ton; under 2 in. but not under 1 in. in length, £5 a ton; under 1 in. in length, £6 a ton.

The Committee report that the specific duty of £3 a ton on wire nails and staples, imposed in February, 1933, has not appreciably checked imports. The present duties on nails generally afford insufficient protection to the home industry, particularly in the case of the smaller and thinner nails, and it is desirable to impose a graduated scale of specific duties to cover all kinds of nails and tacks.

London Foundry Classes

The winter session of the Sir John Cass Technical Institute is scheduled to open on September 24 and Mr. A. F. Gibbs is once again taking charge of the course in Foundry Practice. The syllabus has been designed to cover the requirements of students sitting for the City and Guilds of London examination, which is held under the patronage of the Institute of British Foundrymen. The classes are held on Monday evenings from 7 to 10 p.m. An auxiliary course on Foundry Drawing and Calculations is held on Wednesdays from 7 to 9.30. We ask every employer in the London area to support this course whole-heartedly by according full facilities for the younger employees to attend.

The Work of Walter Rosenhain*

By J. L. Haughton

Walter Rosenhain was born in Victoria, Australia, in 1875, and graduated as a civil engineer in Melbourne University in 1897. After spending three years at Cambridge as 1851 exhibitioner, he worked for some time at Messrs. Chance Bros.' optical glass works, and in 1906 he became head of the Metallurgy Department of the National Physical Laboratory. These three subjects, engineering, optical glass and metallurgy, were always his chief interests in life, but the greatest of these was metallurgy. He wrote a text-book on glass manufacture, while his "Introduction to Physical Metallurgy" has a much greater bias towards engineering than any other book on metallography. He was at one time or other President of the Optical Society and of the Institute of Metals, and Vice-President of the International Association for Testing Materials in 1931. He would have been President at the meeting which it was proposed to hold in London this year had he lived. The first Paper which he published (in 1897) dealt with a method of determining the specific heat of a liquid, while the last one was read last year before the Institute of Metals, and discussed "Some Steps in Metallurgical Progress."

Work in Optical Glass

Rosenhain's work on optical glass, important as it was, can be dismissed in a short space in a lecture given to the Institute. His first contact, on a large scale, with the subject appears to have been when he was appointed as optical adviser to Messrs. Chance Bros., of Birmingham, and, doubtless partly as a result of his experience there, he wrote, in 1907, a book on "Glass Manufacture." Two years previously to this he had read a Paper to the Optical Convention on "Possible Directions of Progress in Optical Glass." After the outbreak of the war, when the supply of optical glass from Germany was cut off, the N.P.L. was asked to undertake research on its production in this country, and this was directed by Dr. Rosenhain, who erected an experimental plant in the foundry of the Metallurgy Department for making glass and—what connects this very closely with metallurgical work—for the study and production of refractory materials.

Metallurgical Investigations

Turning now to that part of Rosenhain's work which is of more direct interest to metallurgists, most of the researches which he carried out can be divided into four headings. These must not be taken too rigidly, but they may be broadly stated to deal with:—(*a*) The production of new alloys and improvements in existing ones; (*b*) the study of the structure and constitution of metals and alloys; (*c*) investigations into the effect of strain on metals and alloys; and (*d*) design of apparatus and methods. Out of a total of 99 Papers which he published, the numbers in the above classes are approximately 15, 25, 20 and 14 respectively, the remainder being concerned with optical glass or miscellaneous other subjects.

Dealing first with the production of new alloys and improvements in existing ones, Rosenhain's name is, of course, inseparably connected with Y-alloy, but this was by no means his first contribution to the development of stronger and better non-ferrous metals. In the 9th Report to the Alloys Research Committee of the Institution of Mechanical Engineers, he described the properties of some ternary copper-aluminium-manganese alloys. The work, which was carried out in conjunction with Lantsberry, dealt chiefly with the copper-rich alloys, and showed that, under certain conditions, remarkably high tensile strength and elongation could be obtained from some of these materials. In addition to ordinary tensile tests on the alloys, alternating stress and impact tests were carried out, and, what was much more unusual at that time, tests at high temperatures. This was a continuation of the work on the strength of aluminium-copper alloys at high temperatures which Rosenhain contributed to the discussion on the 8th Report. Abrasion tests, and hardness tests by the sclerescope, which was then a very new machine, were also undertaken, and the results obtained with the sclerescope were correlated with the values given by the normal Brinell machine.

A Precursor of Duralumin

Whilst the greater part of the report dealt with copper-rich material, that section which was concerned with the alloys of the series high in aluminium is perhaps of greater interest in view of later developments. The alloy which was found to be the best of those examined contained 3 per cent. Cu and 1 per cent. Mn, and Rosenhain pointed out in later years that duralumin, which contains 3.5 to 5 per cent. Cu and 0.5 to 1 per cent. Mn, with a certain amount of magnesium as well, was the logical development of the former, and that, had the results published in the 9th Report been utilised, this country might have had the credit for the discovery of what is still one of the most successful of light alloys.

The 9th Report has been referred to somewhat fully here, as it was precursor of a number of similar Papers dealing with the mechanical properties of alloys. The next most important was published, in collaboration with Archbutt, as the 10th Report of the A.R.C., and dealt with the alloys of aluminium and zinc. While none of the alloys mentioned in this report has proved of great value in practice, it has been invaluable as the starting point for other investigations which led to the development of some of the best-known alloys, such as "A," "E" and "L5." The report is also of interest as introducing for the first time the extremely valuable property known under the somewhat unfortunate name of "Specific tenacity," which is obtained by dividing the ultimate stress of a metal in tons per sq. in. by the weight of a cub. in.

The War Period

After the publication of the 10th Report, work was carried out on the ternary alloys of aluminium, copper and zinc, and had reached an advanced state when the war broke out. Rosenhain was out of the country at the time, having gone to Australia with the British Association, and two out of the four remaining members of the scientific staff of the metallurgy division were called to the colours. On his return Rosenhain threw all his energy into the service of the country. The study of the aluminium-copper-zinc alloys was energetically pushed forward, and the scope of the research was extended to include many other alloys of aluminium. This work, and indeed much more of the same kind which was carried out at the N.P.L., was greatly facilitated by the fact that just prior to the outbreak of war a rolling mill had been installed in the department. This installation was characteristics of Rosenhain's foresight and of his determination that the equipment of his department should be second to none.

It was naturally not possible to publish, until after peace was signed, any of the work done during the war on the production of new alloys, so that a long interlude of eight years occurs between the dates of publication of the 10th and 11th Reports, and it was not till 1921 that the latter appeared under the names of Rosenhain, Archbutt and Hanson. It is stated in the introduction that "any attempt to give an account of the work in the fully-detailed manner adopted in earlier Reports would have been impossible, owing to the prohibitive bulk of such a Paper." As it is, the Report is an impressive volume of more than 250 pages, and it contains details of the development of Y-alloy, of 3/20, and of many others whose names are everyday words with aircraft and internal-combustion-engine constructors.

At about the same time Rosenhain and his colleagues published Papers on special copper alloys, on bearing metals, on zinc-copper-aluminium alloys and on many other practical subjects connected with new alloys or the improvement of existing ones, while later he published work dealing with gas removal in aluminium castings and with alloys (mainly ferrous) for use at high temperatures.

Structure and Constitution of Metals and Alloys

Rosenhain's earliest constitutional work was done at a time when Heycock and Neville had finished most of their work on alloy systems, and when their magnificent research on the copper-tin system was towering head and shoulders above all other similar investigations. A steady stream of constitutional work was pouring from the laboratory of Prof. Tammann. This work was definitely undertaken with the object of establishing approximately the shape of the liquidus curves in as many alloy systems as possible, and as such it was excellent. Unfortunately, many people regarded the results obtained as completely accurately determined equilibrium diagrams. Such they never were, nor was this ever claimed for them, but when other investigators published as equilibrium diagrams, results obtained by the same methods, the whole subject was in danger of falling—indeed, had fallen very far—from the high plane on which Heycock and Neville had set it. Rosenhain's first Paper to this Institute—"Metallographic Investigation of Alloys"—was a fighting criticism of this attitude and a plea for a much higher standard both in the purity of the metals used, in the methods of thermal analysis and in preparation of specimens for microscopic examination. To the end of his life he insisted on a high standard in constitutional work, and it is probably true to say that the great improvement in the work on equilibrium diagrams, which has been so noticeable in the last fifteen years or so, is, at any rate in some measure, due to his influence.

Rosenhain's first constitutional Paper, dealing with the lead-tin system, was read before the Royal Society. The 9th Report to the Alloys Research Committee, to which reference has been made above, contains work on the constitution of the copper-aluminium-manganese alloys. All his other Papers on the subject of metallic equilibria were read before the Institute of Metals. Reference must, however, be made to a group of Papers, read before the Iron and Steel Institute, of which five deal with the constitution of iron-alloy systems. Although Rosenhain's name does not appear as author of any of these Papers, the work was carried out under his direction, and he wrote the introduction to them.

The representation of the constitution of a binary system of alloys presents no difficulties, but in a ternary system a solid model is required. In the 9th Report to the Alloys Research Committee, Rosenhain and Lantsberry used a model made of plaster of Paris to represent the liquidus surface of a part of the system. Such a method is satisfactory where the representation of one surface is all that is necessary, but if much more than this is required, it may become necessary to build a very complicated model in which the different phase volumes fit into each other. Rosenhain first tried to over-

* Autumn Lecture to the Institute of Metals, 1934.

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come the difficulty by building a wire framework and stretching threads across it to represent the various surfaces, in the same way that crystallographers build up models of their crystals. Owing, however, to the fact that many of these surfaces are not planes, but are curved, he soon abandoned the threads and replaced them by wires, thinner than the framework. These wires he coloured to represent the various phases separating on the different surfaces, and in this way he obtained models which showed very clearly the constitution of the alloys.

Investigations into the Effect of Strain on Metals and Alloys

This was a subject very near to Rosenhain's heart, and, paradoxically, it appears at present as if it was the one in which his work will have the least permanent result, though his early research, with Ewing, on slip bands will doubtless ever remain a classic. This was the subject of the Bakerian Lecture to the Royal Society in 1899—a lecture delivered by Ewing and Rosenhain—no small honour for a young man of 24! This work proved conclusively that deformation in metals under stress takes place by slip along the cleavage planes of the crystals, a conclusion which, as far as I am aware, has never been challenged. When, some years later, Beilby showed that during the polishing of a metal, the surface temporarily behaved like a viscous liquid, Rosenhain seized on the idea and carried it much further. He used Beilby's suggestion that the same liquid, vitreous or amorphous phase was formed at the slip surfaces when a crystal was deformed, to explain a large number of the phenomena which occur when a metal is subjected to stress. Further, he suggested that the phenomena occurring at the crystal boundaries of a metal could be explained by assuming the existence of an amorphous film round each crystal. He used the theory to predict other phenomena, and then showed that these phenomena did, in fact, occur. At the present time the amorphous theory is regarded by the majority of metallurgists as not proven, but even if in the end it will be necessary to relegate it to the fate which has befallen innumerable unproved hypotheses, yet it can always be said that in the hands of Rosenhain it not only gave a wonderfully clear explanation of many phenomena that otherwise appeared mysterious, but also that it was the cause of the initiation of a vast amount of work—some of it of the highest order and of outstanding value, not only on the part of Rosenhain and his collaborators in defence of the theory, but also on the part of his opponents. Up to the end Rosenhain believed in the theory, slightly modified in detail, naturally, but substantially as originally advanced, and on the last occasion on which the author saw him, only two or three weeks before his death, he said that he believed the evidence in favour of the amorphous theory was at that time stronger than ever it had been.

Space Lattice Distortion

Rosenhain also published a considerable amount of theoretical work in connection with the lattice distortion metals, and showed how, in many cases the same results were produced, whether the distortion was due to strain or to alloying. For example, both the hardness and the electrical resistivity are increased when a pure metal is strained, but the same result can also be produced by the addition of some other metal which will dissolve in it. Reference should also be made to the work which he carried out on the effect of the rate of deformation on the production of Neumann lines, the rate being varied from a deformation of 10 per cent. in 20 min., carried out in an ordinary tensile-testing machine, to that obtained by firing a detonator mounted on the specimen. Intermediate rates were obtained by more rapid loading in the testing machine and by dropping weights on to the specimen from varying heights.

Design of Methods and Apparatus

Opinions will naturally differ in assessing the relative importance of the various parts of a man's work, but my personal belief is that, next perhaps to his insistence on a high standard, the assistance he rendered to metallurgical workers by providing them with apparatus and methods was Rosenhain's greatest accomplishment. With reference to methods, mention has already been made to his advocacy of the use of wire models for representing ternary equilibria. While he did not introduce the inverse-rate method of plotting cooling curves, and indeed at first opposed it, in favour of the much more sensitive differential method, yet he soon realised that for the vast majority of work the simplicity of the inverse-rate curve more than outweighed its relative lack of sensitivity, and ever afterwards he was an enthusiastic supporter of this method.

It is sometimes a little difficult to differentiate between methods and apparatus. Rosenhain laid great stress, in his early work on the constitution of iron-carbon alloys, on the method of examining the microstructure of samples of the metal which had been annealed *in vacuo* and then quenched very rapidly, and in order to render this possible he designed his quenching apparatus, wherein he made use of the then comparatively new fused-silica tube to enable him to wash the specimen out of the hot furnace with a stream of cold water.

In somewhat the same category is the work carried out by Rosenhain and Murphy on the microstructure of solid mercury and of amalgams which are liquid at ordinary temperatures. It was necessary to freeze these so as to obtain a "polished" surface, etch them while solid and examine the etched surface, still keeping it solid, under the microscope. To do this successfully, as they did, meant devising a new technique and modifying existing apparatus for carrying it out.

The N.P.L. Etching Reagent

Having quenched and polished a metallic specimen it is generally necessary to etch it before examining it under the microscope, and Rosenhain introduced several reagents for this purpose. The story of the discovery of the so-called N.P.L. reagent for mild steel is worthy of recording. Shortly after the author's arrival at the Laboratory, he wanted to etch a piece of bronze to which a piece of mild steel was soldered. He used the standard ferric-chloride reagent, but accidentally immersed the whole specimen in the liquid, and while the copper alloy was, naturally, not attacked, he observed with surprise that the steel was etched in marked bands or layers. The author had no idea what this meant, and took the specimen to Rosenhain, who immediately deduced that the bending was due to uneven distribution of phosphorus in the metal and, apparently without any need for thought, sketched out a programme for investigating the matter. This is outlined in detail, because it was the first of very many occasions when Rosenhain's extreme rapidity of thought impressed the author tremendously.

Rosenhain's design of apparatus was mainly concerned with microscopic work and thermal analysis. The quenching apparatus just mentioned comes, of course, under the first heading, as does the microscope which Messrs. Beck made to his design. When he started his metallurgical work there was no microscope specially made for metallurgical use, and he soon realised the shortcomings of the ordinary instrument for this special work and had one built "on engineering lines," as he expressed it. He also designed two devices for levelling the specimen before transferring it to the microscope stage. The second of these, which works on an optical principle, has very great advantages over all the usual ones, though it is naturally much more costly.

Gradient Furnace and Plotting Chronograph

Rosenhain's two great contributions to apparatus for thermal analysis are the gradient furnace and the plotting chronograph. The first arose out of the realisation that on an inverse-rate thermal curve it is much easier to see the result of small heat evolutions or absorptions when the curve is nearly vertical than when it is at a large angle to the vertical; and, as in any ordinary furnace it requires complicated apparatus to ensure that the rate of change of temperature is uniform over the whole curve, and therefore that the curve is approximately vertical, Rosenhain designed the gradient furnace to give this uniformity. As is now well known, the furnace consists of a lagged tube which is heated at one end and cooled at the other, and the specimen is moved at a constant velocity through the furnace. If the latter has a uniform gradient along it, and the specimen moves steadily and slowly through this gradient, the transfer of heat will be uniform providing there is no anomalous evolution or absorption of heat by the specimen. In the first furnace made the tube was wound over its whole length, the turns being much closer together at one end than at the other, but it was found that the difference in temperature between the ends was much too small, and that quite a satisfactory gradient could be obtained by winding 12 to 15 cms. of one end and water-cooling the other. The winding was first put on the bottom of the furnace, but it was found that serious irregularities in the curve were produced by the convection currents set up in the air inside the tube, while no such trouble was experienced if the winding was placed at the top. Of recent years modifications have been introduced into the apparatus, the specimen being fixed and the furnace moved past it, instead of using a fixed furnace and moving specimen as was originally done, but the principle remains the same.

A word as to the limitation of the gradient furnace may not be out of place here. Where a thermal curve of a metal is to be taken over a short range of temperature—150 to 200 deg. C.—this type of furnace offers little or no advantage over an ordinary one, and further, for temperatures above about 1,000 deg. C. it has not so far been found possible to design a furnace which gives a reasonably-straight line gradient, owing presumably to the greater influence of heat radiated from the hot part of the furnace. In all other cases, however, the use of a gradient furnace is to be recommended, and where it is required to obtain a smooth curve reaching both above and below room temperature, its use is probably essential.

The merits of the plotting chronograph are somewhat different from those of the gradient furnace. It may perhaps be described as a luxury instrument. It is very expensive, and it is possible to get just as good results without its use, but only with a much greater expenditure of time and labour, and where a very large number of thermal curves are taken yearly, as is the case in the N.P.L. and similar institutions, it does not take very long before the plotting chronograph repays its first cost.

The instrument is too well known to metallographists to require any detailed description here; suffice it to say that it plots the points on an inverse-rate curve, the observer having merely to tap a key as the galvanometer spot passes the lines on the scale.

This concludes the discussion on Dr. Rosenhain's purely scientific work. There are, however, at least three other fields of his activity to which reference must be made. The first is his work in connection with international co-operation in science. His high linguistic capacity helped, of course, greatly in this, and those who saw him in the chair at Section A of the International Association for Testing Materials will realise what the Association as a whole will have lost in losing him as President for the 1935 meeting. In addition, however, to the more obvious and public work of this kind, he was continually in correspondence with foreign

(*Concluded on page* 155.)

This Week's News in Brief

Trade Talk

THE WELWYN FOUNDRY, LIMITED, of Welwyn Garden City, Herts, is extending its moulding shops for rain-water goods.

A TABLET IS TO BE UNVEILED in the stairway of the Lyric Buildings, Glasgow, to the memory of the late Sir John Reid, of Glasgow.

OVER £300 DAMAGE was caused by a fire which destroyed a shed at Messrs. Graham's foundry at The Quay, Cork. Strenuous efforts by the city fire brigade saved the main premises from being attacked.

THE STEAMSHIP "Brimm," which recently sprang a leak outside Galway Bay when bound for Sligo with a cargo of galvanised iron, slates and stone-work pipes, has been purchased by the Galway Foundry Company.

AN ORDER for the construction of two small motor coasting vessels has been received by Messrs. John Lewis & Son, Limited, shipbuilders and engineers, Torry, Aberdeen. The vessels are for South of England owners.

BALLYMENA RURAL COUNCIL has passed a proposal for the erection of a steel bridge over the River Bann, between Ballynafay, on the County Antrim side, and Ballynean, on the County Londonderry side, at a cost of £25,000.

MESSRS. SAMUEL DENISON & SON, LIMITED, Hunslet Foundry, Leeds, have received an order from a South African mining company for a 30-ton ore-concentrates rotary-hopper weighing machine with equilibrium control ticket printing mechanism.

A CENTRIFUGAL PUMP made of "Ni-Resist" (nickel-chromium-copper cast iron), operating on caustic solutions in an oil refinery, has given more than 18 months' satisfactory service. Ordinary cast iron, previously used, required replacement about every three months.

DURING THE LAST three months, Scottish shipbuilders have received orders for about 40,000 tons gross, but in the next two months the output of tonnage will probably exceed 120,000 tons. During the present month Clyde shipbuilders launched nine merchant vessels and two warships.

FROM A BERTH adjacent to that occupied by the Cunarder "534," Messrs. John Brown & Company, of Clydebank, launched last week the destroyer H.M.S. "Fortune," built under the Admiralty's 1932 programme. Constructional progress on a sister ship, H.M.S. "Foxhound," is well advanced.

IT IS OFFICIALLY ANNOUNCED that Bridgeness Colliery, belonging to the Bridgeness Company, Limited. Bo'ness, has been sold to Carron Company, Falkirk, and the new owners will take possession on October 1. Bridgeness Colliery is claimed to be one of the oldest in Scotland. It is understood that the Carron Company mean to develop the colliery along modern lines.

THE CLYDE ALLOY STEEL COMPANY, LIMITED, Motherwell, has commenced the erection of new offices on the factory site at Craigneuk. The offices, which will front on the Wishaw back road, are to be of novel design. The gables will be rounded, instead of squared, and the roof will be of glass. It is said that there will be no windows on the ground floor facing the road.

AFTER THE LAUNCHING of the Cunarder on September 26 from Messrs. John Brown's yard at Clydebank, there will be less employment for platers and riveters and other shipyard workers, but that does not mean any great increase in unemployment. Hundreds, if not thousands, of men of other trades will have well over a year's work in fitting out the ship before she sails down the Clyde.

MESSRS. JAMES A. SILVER, LIMITED, have received this month orders for a 56-ft. Diesel-driven yacht. During the month the Roseneath firm launched a 9-ton motor yacht for a North of Ireland owner. Other small-craft launches this month were :—The "Mary Fortune," built by Dickie & Son, Tarbert; the "Alarm," built by Hugh M'Lean, Govan; and two fishing boats for British owners built by Walter Reekie, St. Monans.

MESSRS. COLVILLES, LIMITED, are completing an order at their Dalzell Works, Motherwell, for boiler plates for the Soviet Government, amounting to £8,250. The plates are of standard size and each plate will have the emblem of the Soviet—the hammer and the sickle—stamped on it. A Soviet inspector has been in attendance at the works. The cogging mill at Messrs. Colville's works is now working six instead of five shifts per week, and more men are having constant employment.

LOAN GUARANTEES announced by the Free State Government include the following :—Samuel E. Holmes, Limited, Monasterevan, County Kerry, for the acquisition and installation of plant and machinery for the manufacture of black bolts and nuts and the provision of working capital—£3,000 for 12 years. Metal Products, Limited, Cork, for the acquisition and installation of additional plant and machinery for the manufacture of black bolts and nuts and provision of working capital—£4,000 for 12 years.

Obituary

MR. FRANK J. REES, managing director of the Llanelly Steel Company (1907), Limited, died at his residence in Tenby on Tuesday, August 28. His death was unexpected. Mr. Rees was one of the leaders of the iron and steel trade in South Wales. Besides being managing director of the Llanelly Steel Company, he was director of several companies in South Wales. He was President of the Royal Metal Exchange, Swansea, chairman of the South Wales Siemens Steel Association, and a member of the National Committee for the reorganisation of the iron and steel industry. He was an ex-Mayor of Llanelly, and last February was honoured with the freedom of the town in recognition of his great public work and services to the town. He was Llanelly's fourth freeman. In 1928 he was High Sheriff of Carmarthenshire. He was 54 years of age and started his commercial life as an office boy with the firm of which he ultimately became managing director.

THE LATE MR. FRANK REES.

THE DEATH OCCURRED last week, in Ruchill Hospital, Glasgow, of Mr. David Pettigrew, Greenhead Street, who was a steel dresser with the Newton Steel Works for many years. He was at one time chairman of the Cambuslang Trades Council.

THE DEATH OCCURRED at Glasgow last week of Mr. Robert Mason, of Braehead, Monkton, Ayrshire, who was for many years on the staff of Messrs. P. & W. MacLellan, Limited, Glasgow. Mr. Mason was a governor of the Victoria Infirmary, Glasgow.

THE DEATH OCCURRED, in Edinburgh, of Mr. Robert Pender Whitelaw, a native of Stirling, who was for a long period a consulting engineer on the Rand. At one time employed in Messrs. Murray & Paterson's engineering works at Whifflet, Coatbridge, he went to South Africa, to become a consulting engineer, particularly on bridge work.

Personal

MR. WILLIAM CUTHBERT, chairman of the Clyde Shipping Company, attained recently the jubilee of his connection with the company. In celebration of the occasion, a cruise was made down the Clyde on one of the company's steamers, the "Longships."

Will

STEWART, ARCHIBALD, The Close, Oakham, assistant secretary at the Corby Works of Stewarts and Lloyds, Glasgow £6,020

The Work of Walter Rosenhain

(*Concluded from page* 154.)

metallurgists, acting as the apostle of British metallurgy abroad and at the same time advocating the claims of Continental work in this country.

Non-Scientific Work

Secondly, Dr. Rosenhain's non-scientific work at the National Physical Laboratory was remarkable. He came to the Laboratory when the Metallurgy Department was housed in the kitchen of Bushy House, and had a total scientific staff of four, and left it with a staff of about 70, housed in a large three-storey building and several subsidiary ones, and this increase was in large measure due to Rosenhain's energy and enthusiasm and his capacity of communicating this enthusiasm to his staff. It must also be remembered that the building up to this great Department was carried out while the builder was hard at work in other directions—serving on innumerable committees, carrying out the work on international co-operation, referred to above, working for the good of the Institute of Metals, and many other such things.

This brings us to the third field of Rosenhain's activity—his work in connection with the Institute of Metals. He read a Paper—which aroused considerable controversy—at the first meeting, and three years later was elected to the Council. For the next 21 years, that is, until a few months before his death, his guiding influence was always felt, and he was in no small way responsible for the high position the Institute occupies in the metallurgical world. He was, as most of us know, President during the years 1928-30, and was, over very long periods, chairman of various committees of its Council. He was always ready to work for the well-being of the Institute, and was continually being called on by his colleagues in the Council to undertake difficult or critical correspondence for the Institute—more especially, though by no means exclusively, in connection with foreign matters.

A lecture dealing with the work of a man is no place for referring in detail to his personal characteristics, but I feel compelled to mention one thing—his approachableness by members of his staff, which was a very marked and greatly appreciated trait of his. In discussions at meetings he may sometimes have appeared very formidable, perhaps even unduly fierce, but there was no ill-feeling behind the fierceness—only a keen desire that nothing which he did not regard as first class should pass unchallenged.

In this brief lecture, the author has attempted the impossible—to do justice to the memory of a great man. Those who knew him well will probably realise more than the others how far he has failed. But while the man has gone, his work remains *monumentum aero perennius*.

THE NEW torpedo-boat destroyer "Escapade," built by Scott's Shipbuilding & Engineering Company, Limited, Greenock, for the British Admiralty, carried through acceptance trials on the Clyde this week, and left for the South to go into commission. A sister ship, the "Escort," is at present being fitted out by the same firm.

Raw Material Markets

Trading in pig-iron has been well maintained, although there has been no great expansion as yet. A number of foundries have entered into contracts to cover their winter supplies and this movement is expected to develop, as the immediate outlook in the foundry trade is, generally speaking, quite good. The export demand for British iron and steel has shown refreshing indications of expansion. Further orders have been received from the Dominions, Russia and the Far East.

Pig-Iron

MIDDLESBROUGH.—The output of Cleveland pig-iron is fully taken up by the current demand. Additions which had to be made to unsold stocks during the local holiday period represent a comparatively small total, owing to the heavy demand which has been experienced from Scottish consumers. The latter remains one of the most encouraging features of the Cleveland iron trade. Export business is also picking up in one or two directions. Local consumption remains steady. There has been no change in quotations to home consumers.

The demand for East Coast hematite is gradually expanding, there having been a resumption of shipments to South Wales. Substantial export sales have also been made. There has been no departure from the makers' minimum of 68s. per ton for No. 1 grade, delivered Middlesbrough. For other areas the fixed delivered prices are:—North-East Coast, 70s.; Scotland, 75s.; Lancashire, 76s.; Birmingham, 79s. per ton.

LANCASHIRE.—Contract buying of foundry in this area has so far been rather slow, but the pace should quicken shortly, as a number of old agreements are due to expire within the next week or two. Pig-iron prices are steady on the basis of 74s. for Lancashire deliveries of Derbyshire, Staffordshire and North-East Coast brands of No. 3, 72s. 6d. for Northamptonshire and about 82s. 6d. for Scottish No. 3.

MIDLANDS.—An active autumn is generally looked forward to by the foundry trade in this area, particularly the light-castings section. A meeting of the Pig-iron Producers' Association was held last week, but, as was generally anticipated, no alterations in values were made; therefore, the minimum prices applicable to this area, including delivery to Birmingham and Black Country stations, are still 67s. 6d. for Northants No. 3 and 71s. for Derbyshire, Lincolnshire and North Staffs No. 3, which prices are subject to a small rebate to large consumers. There are no changes in hematite prices. East Coast and West Coast irons are controlled in price at 78s. and 84s. 6d. respectively, delivered this area for No. 3, but Welsh hematite is not controlled in any way and is offered at about 1s. below the East Coast price. General engineering iron varies in price according to locality. Scottish No. 3, which is in the low-phosphorus category, is offered at about 85s. to 87s. 5d., while other irons of similar analysis are quoted at this level up to 95s., with medium-phosphorus iron at 73s. to 80s. The current price for special refined iron for Diesel engine and similar work is from £5 10s. to £6 15s., according to analysis and tonnage.

SCOTLAND.—Dealing in pig-iron has remained quiet. There has been no departure from the official minimum of 70s. f.o.t. furnaces for No. 3 Scottish foundry, with 2s. 6d. extra for No. 1. The light-castings trade remains active, and large quantities of Cleveland iron continue to be shipped into Scotland. Official quotations are unchanged at 67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Glasgow for No. 3 Middlesbrough foundry iron, other English iron being obtainable at slightly lower figures. A blast furnace has been laid off for repairs, bringing the total number in operation in Scotland down to 14.

Coke

The foundry-coke market remains very firm. There is no possible chance of lower prices obtaining, and many consumers have therefore taken cover as far as the ovens will allow them to. Quotations for delivery in the Birmingham area are as follow:—Best Durham coke, 36s. to 40s.; Welsh, 37s. 6d. to 45s.; Scottish, 40s. to 41s. per ton.

Steel

The recent improvement in business has been maintained, and not only has there been a larger volume of inquiry in circulation, but trading has been more active than for several weeks past. In the semi-finished steel department, the demand has improved, and the competition of imported Continental steel in the home market seems to have declined. There is an increase in the amount of inquiry from consumers, and prices in this section of the market have a firm tendency. In the finished-steel market, steady conditions have ruled, and most of the works are well off for orders. The demand is largely on home account, but lately the export side of the market has become more active, although most of the transactions have been confined to small tonnages. An encouraging feature of the situation is that the steel requirements of the constructional and heavy-engineering trades appear to be increasing.

Scrap

A slightly firmer tone is noticeable generally in the scrap markets. In the Cleveland area, heavy metal is at 50s. to 51s., good machinery metal at 52s. 6d., and light metal at about 42s. There is a steady demand for cast-iron scrap in the Midlands at unchanged prices. In South Wales there is a better call for both heavy and light cast-iron scrap, at 47s. 6d. and 41s. to 42s. 6d. per ton respectively, but there is still only a weak demand for machinery metal at 50s. to 52s. 6d., and sales are limited. In Scotland, good clean machinery scrap continues to sell at 53s. 6d. to 55s. per ton, with ordinary cast-iron scrap at 51s. 6d. to 52s. 6d.

Metals

Copper.—Consumption of copper in this country keeps up to a fairly satisfactory level, and a fair demand has been experienced from users during the past week. Part of this buying may be attributed to nervousness following the recent fluctuations in the exchange. The uncertain tendency of sterling makes the outlook in the copper market very obscure.

Daily market prices:—

Cash.—Thursday, £28 5s to £28 6s. 3d.; Friday, £28 5s. to £28 6s. 3d.; Monday, £27 17s. 6d. to £28; Tuesday, £28 to £28 1s. 3d.; Wednesday, £27 18s. 9d. to £28.

Three Months.—Thursday, £28 12s. 6d. to £28 13s. 9d.; Friday, £28 12s. 6d. to £28 15s.; Monday, £28 5s. to £28 6s. 3d.; Tuesday, £28 7s. 6d. to £28 8s. 9d.; Wednesday, £28 5s. to £28 6s. 3d.

Tin.—During last month the "total visible supply" of tin is estimated to have shown a fall of about 800 tons, to about 15,300 tons. Business on the London market has been rather restricted, due largely to the unsettled conditions prevailing outside this country, particularly in America, where the position seems to have taken a turn for the worse during the last two or three weeks. However, the cut which was recently made in production quotas helps to keep prices firm.

Messrs. Rudolf Wolff report that "Trade demand in this country is satisfactory and a moderate business with consumers is experienced on the Continent, though quiet conditions still prevail in the United States of America, but according to reports from that country there should shortly be some definite expansion in demand on the part of consumers for, having in view the dull market there for some time now, stocks in consumers' hands must have been very largely reduced and, with the advent of the autumn months, there should be in any case a moderate improvement in consumption."

Price fluctuations:—

Cash.—Thursday, £228 to £228 5s.; Friday, £228 17s. 6d. to £229; Monday, £229 17s. 6d. to £230; Tuesday, £230 2s. 6d. to £230 5s.; Wednesday, £228 15s. to £229.

Three Months.—Thursday, £227 5s. to £227 10s.; Friday, £227 12s. 6d. to £227 17s. 6d.; Monday, £228 10s. to £228 15s.; Tuesday, £228 17s. 6d. to £229; Wednesday, £227 15s. to £227 17s. 6d.

Spelter.—There has been little or no improvement in the actual consumption of this metal, and a decided weakness has developed in prices. There has been a certain amount of forward buying by consumers.

Day-to-day quotations:—

Ordinary.—Thursday, £13 16s. 3d.; Friday, £13 13s. 9d.; Monday, £13 7s. 6d.; Tuesday, £13 6s. 3d.; Wednesday, £13 3s. 9d.

Lead.—"The demand has been keener and the price, after falling owing to heavy sales on the market, recovered to £10 16s. 3d. for November, at which level it was quite firm. In America the market improved temporarily for sentimental reasons, but afterwards relapsed again to its former level. On the Continent there has been a fair amount of inquiry, but business is still hampered by exchange restrictions," report Messrs. Brandeis, Goldschmidt.

Price fluctuations have been as follow:—

Soft Foreign (Prompt).—Thursday, £10 16s. 3d.; Friday, £10 13s. 9d.; Monday, £10 8s. 9d.; Tuesday, £10 10s.; Wednesday, £10 10s.

Contracts Open

Argentine, September 18.—Air compressor, for the Argentine State Oilfields Department. The Department of Overseas Trade. (Reference G.Y. 14,194.)

Darlington, September 14.—Cast-iron pipes, 2 in. to 6 in. dia., for the Durham County Water Board. Mr. W. Read Ward, clerk to the Board, 77, Northgate, Darlington.

Leek, September 17.—4,900 yds. of 10-in. cast-iron pipes and specials, for the Urban District Council. The Water Engineer, Mr. W. E. Beacham, Town Hall, Leek.

Charminster.—3,200 yds. of mains and fittings, for the Dorchester Rural District Council. Mr. H. O. Lock, clerk to the Rural District Council, 53, High West Street, Dorchester.

Bracebridge, September 10.—Steam-driven turbine pump, a 6-in. steel flanged main and hydrant fittings, etc., for Bracebridge Mental Hospital. Mr. H. E. Page, 5 and 6, Bank Street, Lincoln, Clerk to the Committee.

CAST IRON FLANGED PIPES
2 in.–12 in. & CONNECTIONS. to 24 in. dia.
WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.
JAMES & RONALD RITCHIE, LTD.,
Telephone: 3852 (2 Lines). MIDDLESBROUGH. Telegrams: "Ritchie, Middlesbrough."

Consignment, for Export, of several hundred tons of CHILLED ROLLS made by MESSRS. JOHN LYSAGHT, LTD., WOLVERHAMPTON.

The basis of the mixture used for these Castings was GENUINE COLD BLAST PIG IRON.

Practical Experts say that, on remelting, "Virgin" (i.e. All-Mine Blast Furnace) Pig Iron improves, whereas artificial or synthetic iron deteriorates in quality *and strength*. And of all "Virgin" pig irons, none is as strong and tough *and dependable* as Cold Blast. That is why so many up-to-date iron foundries still prefer our iron for their highest grade castings. It gives an extra margin of strength, and reduces the risk of defects to a minimum.

GENUINE
COLD BLAST PIG IRON

THE EARL OF DUDLEY'S ROUND OAK WORKS, LTD.
BRIERLEY HILL, STAFFS.
Brand: "DUD·L.N.F'ces·DUD"

M. & W. GRAZEBROOK, LIMITED
DUDLEY, WORCS.
Brand: "GRAZEBROOK"

THE LOW MOOR IRON CO., LTD.,
NEW WORKS, LOW MOOR, BRADFORD - YORKSHIRE
Brand: "LOWMOOR C.B."

RAW MATERIALS—PRICE LIST

(Wednesday, September 5, 1934)

COPPER

	£	s.	d.
Standard cash	27	18	9
Three months	28	5	0
Electrolytic	31	0	0
Tough	29	15	0
Best selected	30	5	0
Sheets	58	0	0
India	40	15	0
Wire bars	31	10	0
Ingot bars	31	10	0
H.C. wire rods	34	5	0
Off. av. cash, August	28	7	$10\frac{1}{11}$
Do., 3 mths., August	28	15	$1\frac{3}{64}$
Do., Sttlmnt., August	28	7	$10\frac{1}{11}$
Do., Electro, August	31	14	$1\frac{1}{22}$
Do., B.S., August	31	9	$8\frac{21}{64}$
Do., wire bars, August	31	18	$7\frac{7}{11}$
Solid drawn tubes			$9\frac{1}{2}$d.
Brazed tubes			$9\frac{1}{2}$d.
Wire			$6\frac{1}{4}$d.

BRASS

Solid drawn tubes	$8\frac{3}{4}$d.
Brazed tubes	$10\frac{1}{2}$d.
Rods, drawn	$8\frac{1}{2}$d.
Rods, extd. or rlld.	$4\frac{1}{4}$d.
Sheets to 10 w.g.	7d.
Wire	$7\frac{1}{2}$d.
Rolled metal	$6\frac{1}{2}$d.
Yellow metal rods	$4\frac{1}{2}$d.
Do. 4 × 4 Squares	$5\frac{3}{4}$d.
Do. 4 × 3 Sheets	$5\frac{3}{4}$d.

TIN

	£	s.	d.
Standard cash	228	15	0
Three months	227	15	0
English	229	0	0
Bars	230	15	0
Straits	229	0	0
Australian (nom.)			—
Eastern	228	10	0
Banca	229	15	0
Off. av. cash, August	228	4	$1\frac{17}{22}$
Do., 3 mths., August	228	1	$5\frac{5}{11}$
Do., Sttlmt., August	228	5	$8\frac{7}{11}$

SPELTER

	£	s.	d.
Ordinary	13	3	9
Remelted	14	0	0
Hard	11	0	0
Electro 99.9	15	16	3
English	14	0	0
India	13	0	0
Zinc dust	17	0	0
Zinc ashes	3	0	0
Off. aver., August	13	14	$4\frac{1}{2}$
Aver. spot, August	13	13	$7\frac{7}{11}$

LEAD

	£	s.	d.
Soft foreign ppt.	10	10	0
Empire (nom.)	11	5	0
English	12	10	0
Off. average, August	10	18	$5\frac{9}{64}$
Average spot, August	10	16	$5\frac{1}{22}$

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	23	5	0
Do., V.M. ex whse.	21	10	0
Rods	27	5	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	43	0	0 to	45	0	0
Chinese, ex-whse.				36	10	0
Crude					—	

QUICKSILVER

	£	s.	d.	£	s.	d.
Quicksilver	11	2	6 to	11	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£13 0 0
75%	£18 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	5/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£16 0 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£29 15 0
4/6% car.	£23 0 0
6/8% car.	£21 12 6
8/10% car.	£21 12 6
Ferro-chrome—	
Max. 2% car.	£35 10 0
Max. 1% car.	£38 10 0
Max. 0.70% car.	£41 5 0
70%, carbon-free	10d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/- lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 5 0
Metallic manganese—	
94/96% carbon-free	1/2 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{9}{16}$ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	2	13	6 to	2	15	0
Bundled shrngs.				2	7	6
Mixed iron and steel				2	8	0
Heavy cast iron				2	7	6
Good machinery	2	10	0 to	2	12	6
Cleveland—						
Heavy steel				2	10	0
Steel turnings				1	15	0
Cast-iron borings				1	8	0
Heavy forge				2	10	0
W.I. piling scrap				2	5	0
Cast-iron scrap	2	10	0 to	2	12	6
Midlands—						
Light cast-iron scrap				2	7	6
Heavy wrought iron				2	17	6
Steel turnings, f.o.r.				1	12	6
Scotland—						
Heavy steel	2	10	0 to	2	11	3
Ordinary cast iron				2	12	0
Engineers' turnings				1	19	6
Cast-iron borings				1	19	6
Wrought-iron piling				2	11	3
Heavy machinery	2	15	0 to	2	16	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	25	0	0
Brass	16	10	0
Lead (less usual draft)	9	10	0
Tea lead	7	0	0
Zinc	9	0	0
New aluminium cuttings	66	0	0
Braziery copper	22	0	0
Gunmetal	22	0	0
Hollow pewter	145	0	0
Shaped black pewter	110	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	68/-
Hematite M/Nos.	67/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
E.C. hematite	80/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/6
Clyde, No. 3	82/6
Monkland, No. 3	82/6
Summerlee, No. 3	82/6
Eglinton, No. 3	82/6
Gartsherrie, No. 3	82/6
Shotts, No. 3	82/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	9	12	6 to	9	15	0
Nut and bolt iron	7	10	0 to	8	0	0
Hoops			£10 10 0 and up.			
Marked bars (Staffs) f.o.t.			12	0	0	
Gas strip			10 10 0 and up.			
Bolts and nuts, ¾ in. × 4 in.			14	0	0	

Steel—	£	s.	d.	£	s.	d.
Plates, ship, etc.	8	15	0 to	8	17	6
Boiler plts.	8	0	0 to	8	10	0
Chequer plts.				10	7	6
Angles				8	7	6
Tees				9	7	6
Joists				8	15	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ⅜ in. (Untested)				8	12	0
Flats—8 in. wide and over				8	12	6
,, under 8 in. and over 5 in.				8	17	6
Rails, heavy	8	5	0 to	8	10	0
Fishplates	12	5	0 to	12	10	0
Hoops (Staffs)				9	7	0
Black sheets, 24g. (4-t. lots)				10	10	0
Galv. cor. shts. (,,)				13	0	0
Galv. flat shts. (,,)				13	10	0
Galv. fencing wire, 8g. plain				14	10	0
Billets, soft				5	10	0
Billets, hard	6	17	6 to	7	2	6
Sheet bars	5	2	6 to	5	7	6
Tin bars	5	2	6 to	5	7	6

PHOSPHOR BRONZE

	Per lb. basis
Strip	9d.
Sheet to 10 w.g.	10d.
Wire	11½d.
Rods	10d.
Tubes	13d.
Castings	11d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1¼ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Bessemer	20.76
Malleable, Valley	18.50
Grey forge, Valley	18.25
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	20/- to 25/-
,, furnace	17/6
Midlands, foundry	—
,, furnace	—

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		18/2
,,	28×20	,,	36/4
,,	20×10	,,	26/1½
,,	18¾×14	,,	18/9
C.W.	20×14	,,	15/9½
,,	28×20	,,	33/3
,,	20×10	,,	22/6
,,	18¾×14	,,	15/9½

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.	£	s.	d.
Pig-iron	6	0	0 to	7	0	0
Bars-hammered, basis	£16	0	0 to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0 to	£16	0	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£30	0	0 to	£31	0	0
Faggot steel	£18	0	0 to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0 to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£	s.	d.		
Aug. 30 ..	28	5	0	inc.	3/9
„ 31 ..	28	5	0	No change	
Sept. 3 ..	27	17	6	dec.	7/6
„ 4 ..	28	0	0	inc.	2/6
„ 5 ..	27	18	9	dec.	1/3

Electrolytic Copper

		£	s.	d.		
Aug. 30 ..	31	10	0	inc.	10/–
„ 31 ..	31	10	0	No change	
Sept. 3 ..	31	0	0	dec.	10/–
„ 4 ..	31	0	0	No change	
„ 5 ..	31	0	0	„ „	

Standard Tin (cash)

		£	s.	d.		
Aug. 30 ..	228	0	0	inc.	25/–
„ 31 ..	228	17	6	„	17/6
Sept. 3 ..	229	17	6	„	20/–
„ 4 ..	230	2	6	„	5/–
„ 5 ..	228	15	0	dec.	27/6

Tin (English ingots)

		£	s.	d.		
Aug. 30 ..	228	5	0	inc.	25/–
„ 31 ..	229	0	0	„	15/–
Sept. 3 ..	230	5	0	„	25/–
„ 4 ..	230	10	0	„	5/–
„ 5 ..	229	0	0	dec.	30/–

Spelter (ordinary)

		£	s.	d.		
Aug. 30 ..	13	16	3	inc	2/6
„ 31 ..	13	13	9	dec	2/6
Sept. 3 ..	13	7	6	„	6/3
„ 4 ..	13	6	3	„	1/3
„ 5 ..	13	3	9	„	2/6

Spelter (Electro, 99.9 per cent.)

		£	s.	d.		
Aug. 30 ..	16	6	3	inc.	2/6
„ 31 ..	16	3	9	dec.	2/6
Sept. 3 ..	16	0	0	„	3/9
„ 4 ..	15	18	9	„	1/3
„ 5 ..	15	16	3	„	2/6

Zinc Sheets (English)

		£	s.	d.		
Aug. 30 ..	23	5	0	No change	
„ 31 ..	23	5	0	„	„
Sept. 3 ..	23	5	0	„	„
„ 4 ..	23	5	0	„	„
„ 5 ..	23	5	0	„	„

Lead (English)

		£	s.	d.		
Aug. 30 ..	12	10	0	No change	
„ 31 ..	12	10	0	„	„
Sept. 3 ..	12	10	0	„	„
„ 4 ..	12	10	0	„	„
„ 5 ..	12	10	0	„	„

AVERAGE PRICES OF GALVANISED CORRUGATED SHEETS (NORTH OF ENGLAND).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1904	11 5 0	11 5 0	11 5 0	11 5 0	10 15 0	10 15 0	10 15 0	10 15 0	10 5 0	10 5 0	10 5 0	10 5 0	10 15 0
1905	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	10 7 6	11 0 0	11 5 0	11 15 0	12 0 0	10 15 0
1906	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 12 6	12 12 6	12 15 0	12 15 0	12 15 0	13 5 0	12 13 1¾
1907	13 5 0	13 5 0	13 15 0	13 15 0	13 15 0	13 15 0	13 17 6	13 17 6	13 17 6	13 2 6	13 2 6	13 2 6	13 10 10
1908	13 2 6	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 11 0¼
1909	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 16 8
1910	11 15 0	12 5 0	12 5 0	11 15 0	11 10 0	11 10 0	11 12 6	11 12 6	11 12 6	11 12 6	11 10 0	11 10 0	11 18 4
1911	11 5 0	11 1 3	10 15 0	10 15 0	10 13 9	10 10 0	10 13 9	11 0 0	11 5 0	11 5 0	11 5 0	11 7 0	10 19 7½
1912	11 10 0	11 10 0	11 10 0	11 15 0	12 5 0	12 5 0	12 5 0	12 5 0	12 5 0	12 12 6	12 18 0	12 15 0	12 2 11½
1913	12 15 0	12 15 0	12 15 0	12 11 3	11 18 0	11 15 0	11 15 0	11 15 0	11 15 0	11 3 0	11 0 0	11 2 8	11 18 4
1914	11 7 0	11 7 6	11 7 6	11 5 7½	11 2 6	10 15 0	10 15 0	12 17 6	14 2 0	13 7 0	11 15 7	11 2 6	11 16 0
1915	11 10 8½	13 12 6	14 8 9	15 0 6	17 17 6	20 17 6	20 17 6	20 6 3	17 12 6	18 1 0	22 13 9	25 2 0	18 3 4½
1916	26 5 0	27 12 6	28 0 0	28 5 0	29 0 0	29 0 0	28 15 0	28 3 0	28 15 0	28 15 0	28 15 0	28 15 0	28 6 8½
1917	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 15 0	28 0 0	28 0 0	28 0 0	28 11 3
1918	28 5 0	28 15 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	29 0 0	28 13 4
1919	29 0 0	29 0 0	29 0 0	28 0 0	28 10 0	27 7 6	27 5 0	29 3 0	32 0 0	33 0 0	36 10 0	40 8 4	31 5 3½
1920	46 10 0	49 15 0	53 15 0	56 0 0	55 10 0	54 10 0	52 10 0	48 10 0	44 3 4	39 2 6	35 17 6	30 8 0	47 4 3
1921	28 10 0	25 17 6	24 5 0	23 3 4	22 0 0	22 0 0	23 10 0	21 12 6	20 0 0	18 15 0	18 3 9	17 2 0	22 1 7
1922	16 17 6	15 13 9	16 3 0	16 10 0	16 4 4½	15 15 6	15 16 3	16 16 0	16 8 9	16 6 3	17 1 0	17 7 6	16 7 5½
1923	18 3 1½	19 1 11½	19 8 0	19 10 0	19 7 0	19 1 3	18 0 0	18 13 1½	19 0 0	19 3 9	19 2 6	18 19 4½	18 10 2
1924	18 13 6	18 9 4½	18 5 0	17 15 11½	17 3 0	17 19 4½	18 7 6	18 8 1½	18 8 1½	17 19 6	17 11 3	17 10 0	18 0 10½
1925	17 8 6	17 1 6½	16 9 4½	16 12 0	16 9 8½	16 9 4½	16 0 6	16 1 10½	16 5 0	16 7 0	16 12 6	16 15 0	16 11 0½
1926	16 14 4½	16 5 7½	16 0 6	15 11 10½	15 11 3	16 0 0	16 16 0	16 18 9	16 14 0	16 18 9	17 10 0	16 19 0	16 10 0½
1927	16 3 1	15 7 6	15 3 3	15 3 1½	14 14 4½	14 11 6	14 1 10½	14 0 0	13 19 6	13 16 10½	13 13 1½	13 3 9	14 9 10
1928	13 0 0½	13 2 6	13 6 0	13 2 6	13 3 0	13 6 9	13 11 3	13 10 0	13 10 7½	13 12 6	13 11 6	13 10 0	13 8 8½
1929	13 11 0	13 13 1½	13 12 9½	13 10 11½	13 9 3	13 8 9	13 11 6	13 7 6	13 7 6	13 5 6	12 18 9	12 12 9½	13 7 5½
1930	12 5 0	11 15 0	11 19 6	11 18 7	11 18 0	11 17 6	11 17 6	11 17 6	11 16 3	11 12 6	11 8 9	11 5 0	11 15 11½
1931	11 4 0	11 0 0	11 0 0	11 0 0	10 13 9	9 18 9	9 13 6	9 5 3½	8 19 0½	9 16 0	9 8 9	9 4 0½	10 1 10½
1932	9 2 9	9 14 4½	9 16 0	9 13 9	9 12 6	9 12 6	9 11 0	9 4 4½	9 11 3	10 12 6	11 5 0	11 7 0	9 18 7
1933	11 15 0	11 15 0	11 15 0	11 15 0	11 17 6	12 4 0	12 10 0	12 10 0	12 12 6	12 15 0	12 15 0	12 15 0	12 4 11
1934	12 15 0	12 15 0	12 15 0	12 17 6	13 0 0	13 0 0	13 0 0	13 0 0	—	—	—	—	—

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SALES BY AUCTION—*Continued*

By CHAS. A. CHARLTON, F.A.I.

By order of the Proprietors.

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Catalogues in due course can be obtained from Percy Russell, Esq., Chartered Accountant, 8, New Street, Leicester; Messrs. Stokes & Ricks, Incorporated Accountants, Sherwood Buildings, Nottingham; Messrs. Johnstone, Williams & Walker, Solicitors, Weekday Cross, Nottingham; and the Auctioneer, 26, Dennett Street, Nottingham ('Phone: 41405).

SALE by Auction, September 27, 1934. Freehold Factory Site, 18 acres, Burton-on-Trent, adjoining Rail and Canal.—Particulars from JOHN GERMAN & SON, F.S.I., 84, High Street, Burton-on-Trent, or WILDE, SAPTE & COMPANY, 21, College Hill, London, E.C.4.

NOTICE

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The following course of instruction will be given during the Session 1934-35, commencing September 24th, at 7 p.m.

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This course is arranged for those who wish to take the official examination in Foundry Practice and Science held by the City and Guilds of London Institute, in conjunction with the Institute of British Foundrymen: for those who wish to take the examination in Foundry Practice to have their National Certificate in Mechanical Engineering endorsed to that effect: and also for those in the Metallurgical and Allied Industries who wish to obtain a knowledge of Foundry Work.

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